

# Darby's Dream

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## Abstract

The underlying nature of what we call “reality” has a purely mathematical character—and *we* invented the mathematics. Students at all levels should be made aware of this, and of the choice that this presents to every one of us.

## I. INTRODUCTION

Darby had had it! A long day; a long week; a long year, and a long life. Darby lay down, alone, in lower Manhattan. And Darby drifted into his dream:

## II. YOU

You know that you exist! And that is the *only* thing that you know for sure. Descartes: “Cogito ergo sum” — “I think, therefore I am.”

Yet, you are probably extremely confident that, beyond your own mental existence, there is a world out there, including your own physical body. But! You should be cautious about that! We have learned, from physics, that it is not true!

To begin with, you do also have *dreams*, don't you? You do not think that what appears in *dreams* is “real,” do you? Why, then, is it that you *do* think that what you perceive when you are “awake,” as you call it, is real? Surely it is because that which you perceive, when you are awake, is *consistent*. What you perceive when you are “dreaming” is *not* consistent, even within a single dream, much less from dream to dream.

Well, in fact the song is right: “Row, row, row your boat, gently down the stream; Verily, verily, verily, life is but a dream.” A dream, but a consistent one!

Your “awake” perceptions have built up over the years (or the decades, in my case) into a solid picture of what you call the world, and they have given you some idea (or opinion) as to the nature of that world. Perhaps you adhere to a religion that attributes your existence, and that of the world, to a God, where a God is a mind that is vastly more capable than your own.

That “world” of yours, currently contains about 7 billion people. Recent genetic research indicates that all 7 billion of us are descended from only about 50,000 people who lived in East Africa only about 50,000 years ago.

Those 50,000 people were far from being the only people on earth at that time—there were perhaps a million people in those days. But, only the 50,000 have left any descendants at all. It seems that “our tribe” had enormous successive victories over all of the others, leaving those *other* people with no descendants at all.

It is speculation, but it seems likely that the secret of our success was our creation of the

first spoken language, and that a specific genetic change, that occurred only in *our* tribe, led to the development of that first language.

Imagine that you were a kid, in our tribe, at that time! You, and the other kids, create a game. One kid holds up a rock and says “rock.” Likely with a click-click sound (there are still click languages in Africa today). All the other kids run around and pick up rocks and say “rock.” Some kids can’t say it. The kids who *can* speak, form a gang and quickly develop a vocabulary. As the kids grow, *your* gang’s hunting parties are far more successful than those of the kids who cannot speak, and hence cannot easily organize. Few speakers would mate with non-speakers! A few generations would quickly lead to a tribe consisting solely of people who could speak our newly-created language. And that tribe could, and did, defeat all of the other tribes on earth!

Our 7 billion people have done many things over the past 50,000 years, including the development of religions to “explain,” or at least to try to account for, our existence, and that of “the world.” Some religions claim that God directly communicated their religion to man.

But there is another strain of attempted explanation, or understanding, of our existence (and of the world’s existence) and that is the science that we call physics.

Important, but fragmentary, mathematics and science appeared, over the centuries, in many cultures; but only in Europe, in the Middle Ages, did a *systematic* science appear, in a revival of classical Greek ideas on the subject. Systematic science, we have quickly found, builds on itself and covers larger and larger parts of understanding of what we call the external world.

The language of physics, we quickly learned, is mathematics. Many different spoken and written languages are in use around the world, but there is only *one* mathematics, even usually to the symbols that are used to represent the ideas. In fact, it seems clear in retrospect that “languages” are merely “fuzzy math.”

Since the discovery of Einstein’s Theory of Relativity in 1905, a revolution has occurred in our understanding of the power, specifically, of *mathematics* in interpreting for us the nature of the world, and of our own existence.

Not everyone is comfortable with mathematics. Perhaps we, again, have a situation where those who are fluent mathematicians (the “new language” people) will displace those who are not? Somehow? I am, myself, not a mathematician, but I have worked for decades to

achieve understanding of physics using the language of mathematics, with, I think, some degree of success. It has changed my perception of the meaning of existence totally. I want to communicate that change to the reader of the present work, even if he or she is even less mathematical than I am. And, luckily, I think it can be done!

### III. MATHEMATICS

We are fortunate that only minimal mathematics is necessary to convey the enormous power that mathematics has to change our understanding of what we perceive as an external world. And, we are particularly fortunate that almost everyone is familiar with the famous Pythagorean Theorem: because that profound and ancient theorem gives us ... believe it or not ... a doorway into the nature of time itself. And by implication, into the nature of the universe itself.

In teaching Astronomy classes over past years, I have often asked students to suggest items to go on a List of “what is to be explained,” as we humans observe the world.

The list, I initiate myself on the blackboard, with 1) “Matter,” and I then ask the students for contributions toward extending the list. I get Heat, and Air, and Time, and Space, and Smell, and ... you can add to this list yourself!

And then, I ask what item on the entire list (of perhaps 20 items) the students would most like to understand better. The answer that I always get, is *Time*. Time, the most mysterious feature of the universe!

While the most important single discovery that has ever been made, in physics, was the discovery of Quantum Mechanics in 1925, the second most important discovery was our deep insight into the nature of Time. The key discovery was made by Albert Einstein in 1905, but it was only in 1908 that Einstein’s former teacher, Minkowski, pointed out that Einstein’s 1905 Special Relativity provided a specific profound insight as to the fundamental nature of Time itself. And Minkowski’s doorway to that insight—insight into the nature of Time itself—was ... the Pythagorean Theorem!

So now we are going to do some easy mathematics, with the “bait” being: uncovering the true nature of Time! And that, in turn, will lead us to the true nature of the universe.

There are many proofs of the Pythagorean Theorem. We are going to examine exactly two of those proofs.

Why two? Isn't one proof enough? Our *second* proof, not our first proof, will open doors to our own minds, and to the universe, that are staggering in their implications!

Our first proof, is from ancient China: it consists of one word, "Lo!," and the two diagrams of Figure 1.

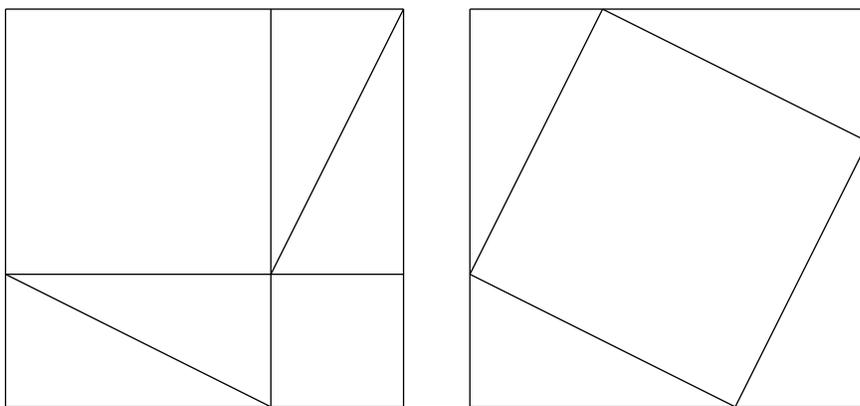


FIG. 1. The "Pythagorean" Theorem from Ancient China

All you have to do is compare the two diagrams, and the proof of the "Pythagorean" Theorem leaps out at you!

Well ... the proof *will* leap out at you, after I've explained! The two large squares (one within each diagram) are equal in area: for if you draw them on a piece of paper, and then cut them out and place them on top of each other, they will cover each other exactly.

Step two: each of the two diagrams is seen to contain four identical triangles: you can check that all 8 triangles are identical by cutting them out, and placing them on top of each other: all 8 are indeed identical.

But if you take equals away from equals, then clearly the two remainders must *also* be equal.

So, take the four triangles away from each of our two diagrams. What is left in the two diagrams, must be equal in area! What is left in one case is a large square that was on the hypotenuse of one of the vanished triangles. What is left, in the other case, is the two squares that were on the other two sides of others of the vanished identical triangles. So: "the square on the hypotenuse is equal to the sum of the squares on the other two sides;"

QED (“Quod Erat Demonstrandum,” or “what remained to be proven.”)

What we have just carried out, is mathematics. In particular, it is “geometry” or “measure of the earth.”

But in addition to geometry, there is another branch of mathematics which we call *algebra*. So, we will now carry out our second proof of the Pythagorean Theorem: this time using, not geometry, but, instead, algebra (Figure 2).

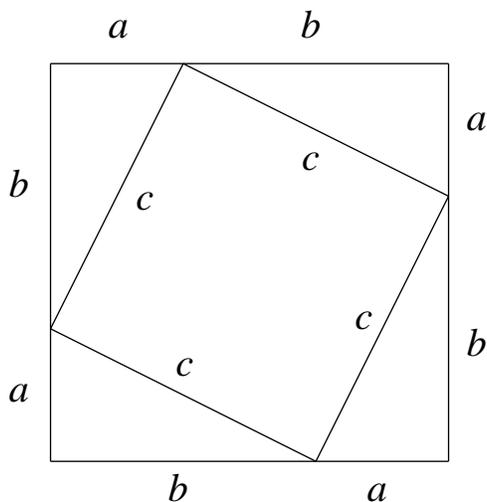


FIG. 2. The Pythagorean Theorem from Algebra

Our new diagram is seen to be identical to one of the two diagrams that we used in our Geometrical proof of the Pythagorean theorem. But this time, unlike last time, we have labeled our diagram with algebraic symbols: letters of the alphabet. Line segments that are the same length (as can be verified by simply cutting them out, and placing them on top of each other) are assigned the *same* algebraic symbol.

We can then use the rules of algebra to determine areas: for rectangles, the area is the product of the two sides; for squares, the area is, well, the “square” of the side! For triangles, the area is “one half of the base  $\times$  the altitude.”

Now, we can carry out the evaluation of the area of the biggest square (that is, of the entire diagram) in two ways. And, of course, our two results must be equal to each other!

One way to get the area, is to note that each side of the biggest square is  $(a+b)$  in length, so that the area of the biggest square is  $(a+b)^2 = a^2 + 2ab + b^2$ , using our knowledge of simple algebra.

The second way is to, first, calculate the total area of the four triangles: each triangle has area  $\frac{1}{2}(a \times b)$  (and then we multiply by four); and then, finally, we add in the area of the big square in the middle, which is  $c^2$ . Our new result is  $2ab + c^2$ .

Our two results must be equal to each other, so we conclude that  $a^2 + 2ab + b^2 = c^2 + 2ab$ . Subtracting  $2ab$  from each side of our equation leaves us with  $a^2 + b^2 = c^2$ , which is the Pythagorean theorem.

Our mathematical labors are over! We are ready to receive our reward!

#### IV. THE NATURE OF TIME

We have proven the Pythagorean Theorem in two dramatically different ways: one using geometry, and one using algebra. Which way is superior?

At first glance, the geometrical proof appears to be far superior. What's good about it, is that the theorem leaps out to the eye, and to the mind, with no use of symbols of any kind, not even words! Simply *look*, once again, at the two diagrams: the Theorem is Proven!

Furthermore, our second proof, involving algebra, *seems* deeply inferior! For where does algebra come from? Not from nature! It is a human invention! We have simply created; or constructed; or defined—this, our algebra—precisely *so that* it *will* give the “right answer” for the Pythagorean Theorem *as we already know it*, from our first proof! It is, on its own, *not a proof at all!*

But amazingly, it is this *second*, the *algebraic*, proof, that, we will see (and soon) is far, far, superior to our first method of proof! For our *new* proof—our *human-invented* “proof”—is pregnant with the secrets of the universe!

Our new proof of the Pythagorean Theorem can easily be extended to three dimensions. In the case of two dimensions, we had  $a^2 + b^2 = c^2$ ; now we have  $+x^2 + y^2 + z^2 = s^2$ . We have represented this, here, using our convenient algebra; but it can surely be proven, perhaps a bit clumsily, using purely geometrical methods in three dimensions.

Perhaps you noticed that + sign in front of the  $x^2$ ? I put it there for a reason that will appear! Conventionally it is omitted, but it is certainly part of the equation: the terms  $+x^2$ , and  $+y^2$ , and  $+z^2$ , could have been placed in any order; there is nothing different about  $x$ .

We now come to the crunch! What would the Pythagorean Theorem be ... in *four* dimensions? In particular, the notion that Time is a fourth dimension comes easily to the

human mind ... I hope that we are getting excited!

We are not the first to get excited at this notion! Possibly the first person to get excited—excited indeed!—at this notion, was the Anglo-Irish mathematician and physicist William Rowan Hamilton. Hamilton even wrote a poem about the idea (Mathesis is the Greek goddess of science):

### THE TETRACTYS

Of high Mathesis, with her charm severe,  
Of line and number, was our theme;  
and we Sought to behold her unborn progeny,  
And thrones reserved in Truth's celestial sphere:  
While views, before attained, became more clear;  
And how the One of Time, of Space the Three,  
Might, in the Chain of Symbol, girdled be:  
And when my eager and reverted ear  
Caught some faint echoes of an ancient strain,  
Some shadowy outlines of old thoughts sublime,  
Gently he smiled to see, revived again,  
In later age, and occidental clime,  
A dimly traced Pythagorean lore,  
A westward floating, mystic dream of FOUR.

I have highlighted in red the intellectual content of Hamilton's poem. Clearly, Hamilton, perhaps the most brilliant physicist who ever lived, was looking at the following equation:  $+x^2 + y^2 + z^2 + t^2 = s^2$  and Hamilton was wondering what change he could possibly make in this equation, to have the fourth item on the left hand side successfully represent time. Using the symbol  $t$  for it does *not* do the trick: mathematically it is quite clear that you have simply introduced a fourth dimension of space, for our fourth item on the left (just like the other three items) is simply the square of a number—and we know that the other three items are all dimensions of space.

I have often asked classes at the University where I teach what change they would make, to accomplish Hamilton's objective. Year after year, some student suggests ... do not read further, dear reader: what would YOU suggest? (Simple! Don't blow it!)

[Do not read further until you are ready to give up, as Hamilton clearly did.]

I have often asked classes at the University where I teach what change they would make, to accomplish Hamilton's objective. Year after year, some student suggests replacing the fourth + sign with a minus sign.

I shake their hands, and I let them know that they have discovered Einstein's Theory of Special Relativity.

Hamilton, the greatest physicist who ever lived, was unable to make that simple leap, which can easily be made today by anyone, if they are just gently prodded!

You will notice that it is *only* through our *human-created algebraic approach*, that this discovery is even conceivable! It could never occur through the non-algebraic Geometrical path!

## V. EINSTEIN'S THEORY OF SPECIAL RELATIVITY

Einstein's theory of Special Relativity is that the Pythagorean Theorem, in the space-time in which we live, is  $x^2 + y^2 + z^2 - t^2 = s^2$  where  $s$  is the separation, in space and time (that is, in the universe), of any two events (events such as, for example, two snaps of your fingers). The distinction between a space dimension and a time dimension is entirely in the *sign* of that item in the Pythagorean theorem.

That equation,  $s^2 = x^2 + y^2 + z^2 - t^2$ , is what Minkowski introduced to the world in 1908! It reproduces every aspect of Einstein's theory of Special Relativity, and it is the most economical way of introducing and presenting that famous and wonderful theory.

And it tells us truly remarkable things about the nature of time, and of the world! All of the well-known and "mysterious" consequences of Special Relativity emerge effortlessly from that one equation (with *no* additional "physics"). Time slowing down! Rocket ships getting shorter in their direction of motion! And all the rest!

We normally use different *units* for distances (*meters*) and for times (*seconds*) but if our equation applies to the world (and it most certainly does) then the *same* units should be used for both. So, we need a conversion factor, call it  $c$ , such that in the equation

$$x^2 + y^2 + z^2 - c^2t^2 = s^2 \text{ the units of all four components are meters.}$$

It is easy to devise an experiment to determine the value of  $c$ : one simply flies clocks, at high speed, around the world, and *measures* by *how much* they are slowed, and then

*calculates* the necessary value of  $c$ . The result? By experiment,  $c$  is ... identical to the speed at which light moves! Which is (nowadays) *defined* as being 299,792,458 meters per second exactly. It is very easy mathematically to show that if our equation applies (and of course it does) then a speed greater than  $c$  simply cannot occur: for *mathematical* reasons! So what we call the speed of light, is not really the speed of light, it is the limiting velocity that is set by the four-dimensional geometry of our universe. Light moves as fast as it can.

Why does the universe care about the mathematics *that we humans* have created? But it does! Algebra, working from our ONE equation of Special Relativity, produces even the atomic bomb! Nature knows our minds! Nature reflects our minds! Nature *is* our minds.

The consequences of Special Relativity are staggering! For example, suppose that  $x^2 + y^2 + z^2 = d^2$  is the (squared) distance from the Sun to our Earth. Our Relativity equation tells us that the interval between the two events of a) a photon of light leaving the Sun, and b) that same photon arriving at Earth,  $t$  seconds later, is  $s^2 = d^2 - c^2t^2$ . But  $d = ct$  of course, and so  $s^2 = d^2 - c^2t^2 = c^2t^2 - c^2t^2 = 0$ . Which is to say that photons do not exist! That is, in its own coordinate system, the photon disappears from the Sun and is absorbed in a leaf here on earth, in no time at all, by its own clock! For the photon, time has slowed down such that there is no passage of time! Ever!

Do we understand this? Yes and no! We certainly cannot fit it into our historical ideas about the nature of time. But all that means is that those ideas were flat wrong. We can very easily calculate *correct* answers using the simple mathematics of Special Relativity. And that is the end of the story! Give up your naïve picture of the universe! It is flat out wrong! Adopt a *physics* picture, which is *proven* true, by *experiment*!

## VI. THE NATURE OF THE UNIVERSE

We have now done all of the mathematics that we need to do to convince (I hope) anyone of the actual nature of the universe. Special Relativity has been tested to high accuracy, and there is no doubt at all that it is correct. And it is purely mathematical in its nature. There is no “physics” at all. The same is true of all of the rest of physics. Every single thing turns out to be mathematical.

And remember! We humans *invented* this mathematics! And nature turns out to “already know” the mathematics that *we* invented! And we can (and have) invented additional

mathematics far beyond the mathematics that is somehow realized as our universe: that is, we humans can conceive and intelligently discuss universes that, as far as we know, do not exist and never have! And we do it all through ... algebra. High School algebra. Oh yes, and also calculus, invented by Leibnitz and Newton.

Has mathematics ever failed us? Yes, it has, but only for a time! Mathematics could describe the rotation of objects in two dimensions, but it completely failed in three dimensions. Perhaps the greatest mathematician who ever lived, Carl Friedrich Gauss, gave up, and decided that space (with its three dimensions) went “beyond mathematics.”

Sigh! Gauss had simply failed to invent vectors, a further extension of mathematics: vectors do the job, simply and completely. Who *did* invent vectors, finally? It was our old friend William Rowan Hamilton, the same man who had missed Special Relativity, even though he was but an inch away from it. And today, vectors are taught to everyone in high school.

We’ve come a long way, baby!

## VII. THE ATOMIC BOMB

Now let me drive home, with an example, how enormous the advance was that occurred with the application of human-invented algebra to our understanding of the so-called universe. For immediately that Albert Einstein had created Special Relativity, that same year (1905) he did the simple algebra that flows out of his marvelous discovery, and produces the famous equation,  $E = mc^2$ . His scientific paper is only two pages long! No additional *physics* of any kind is needed. All that he needed beyond Special Relativity was the known fact that Uranium 235 spontaneously decays into lighter particles, the sum of whose masses is less than that of the Uranium 235. It had been observed that energy appeared when this happened; Special Relativity allowed, for the first time, calculation of the *amount* of that energy: and it gave the right answer! Algebra rules!

It would be easy indeed for me to provide the reader with all the steps of the simple algebra that produces the famous equation  $E = mc^2$ . But my aim is not to write a textbook, but rather, having subjected the reader, above, to the essential core mathematics that is needed to exhibit what the basic idea is, to simply state the astounding results.

## VIII. MATHEMATICS

The mathematics of algebra is not *all* of mathematics. Far from it! Yet not all of mathematics is realized in the world. Let me ask a question that I have never seen asked: what is it that decides what portion of all possible mathematics is actually realized in the world? A specific example: Does the realization of space as numbers extend to infinity? In other words, is it necessarily true that space is infinite? Or must space be finite—so that infinite numbers are *not* realized?

Above, I glibly noted Newton’s invention and use of calculus. That invention was rejected by many mathematicians, in Newton’s time, for good mathematical reasons; calculus survived, and indeed thrived, for the pragmatic reason that *it worked*, in practice, applied to physics!

## IX. QUANTUM MECHANICS

So far, I hope that I have convinced the reader that the universe (as it is revealed by Special Relativity) is dramatically different from the impression of it that we get through our senses. But I promised you, the reader, more than that; I promised that we would see that the universe does not actually exist at all; that it is “in our minds.”

It was the discovery of Quantum Mechanics that led to our realization of that extraordinary truth. Quantum Mechanics is very mathematical indeed, and so it is fortunate that there will be no need for us to consider the mathematics of Quantum Mechanics at all. Why? Because immediately QM was discovered, it not only led to extremely rapid and extensive progress in our study of nature, but it also led to truly *extraordinary* predictions for the results of possible simple *experiments*; experiments that would never have been carried out, without the stimulus of the seemingly absurd predictions that QM made for those experiments.

So, all we have to do is examine those *experiments*—there is no need to examine QM itself!

However, before I show you the experiment that establishes that the universe exists only in your mind, let me say a few words about QM itself anyway. People who choose a career in physics face a traumatic moment at a certain point in their education—it is when they

really study QM. Suddenly physics, which had seemed so practical and so real, dissolves into nothing but a haze of mathematics. It is extremely disconcerting, and many people switch, and become engineers, at that point! QM *seems* utterly unnatural.

Well, QM is *not* unnatural, and is not mysterious at all. My own battle to understand QM resulted in my paper, “Quantum Mechanics Made Transparent<sup>1</sup>,” which appeared in the American Journal of Physics in 1990. I showed that QM is exactly what you expect, if observations have the character of numbers (which they do), and if simple symmetries are present in the observations (which they are, by experiment). The mystery of QM dissolved completely for me at that point. My paper was not a discovery; the same result had been found by others.<sup>2</sup> For some reason that is beyond my comprehension, this result is not well known, and students are left to flounder and, too often, to founder!

OK, I had to say that!

But now, let us get back to business! The experiment that shows the non-existence of the world! This experiment has been carried out many times (and is being carried out further right now). The version of it that is easiest to understand has not yet been carried out, although I expect it will be at some time in the future—but there is no doubt what the result will be. “Easiest to understand” is exactly what we want, of course.

There will be no mathematics at all! Just an experiment! The result of the experiment establishes that there is no actual universe at all, “out there,” despite appearances!

A distant Quasar is located (Figure 3) one billion light years away from us out in the universe. The conventional view (and the one that is frequently used, simply for convenience, by those of us who know better) is that our quasar is emitting photons of light, and that these photons are spreading out into the universe in all directions, each photon moving at a speed of 186,000 miles per second.

We have carefully chosen for our experiment a quasar that just happens to have, located almost directly between that quasar and us (who are located here on Earth), a massive Cluster of Galaxies. Such quasars (and such clusters) do exist!

Because of the curvature of spacetime that is produced by the massive cluster of galaxies (curvature that was predicted by Einstein’s theory of General Relativity, and has been observed to actually occur), some photons reach our telescope via one way around the cluster of galaxies, but others of the photons reach us by other routes around the cluster of galaxies. Two such routes are shown in our diagram, as dashed lines. You can think of each

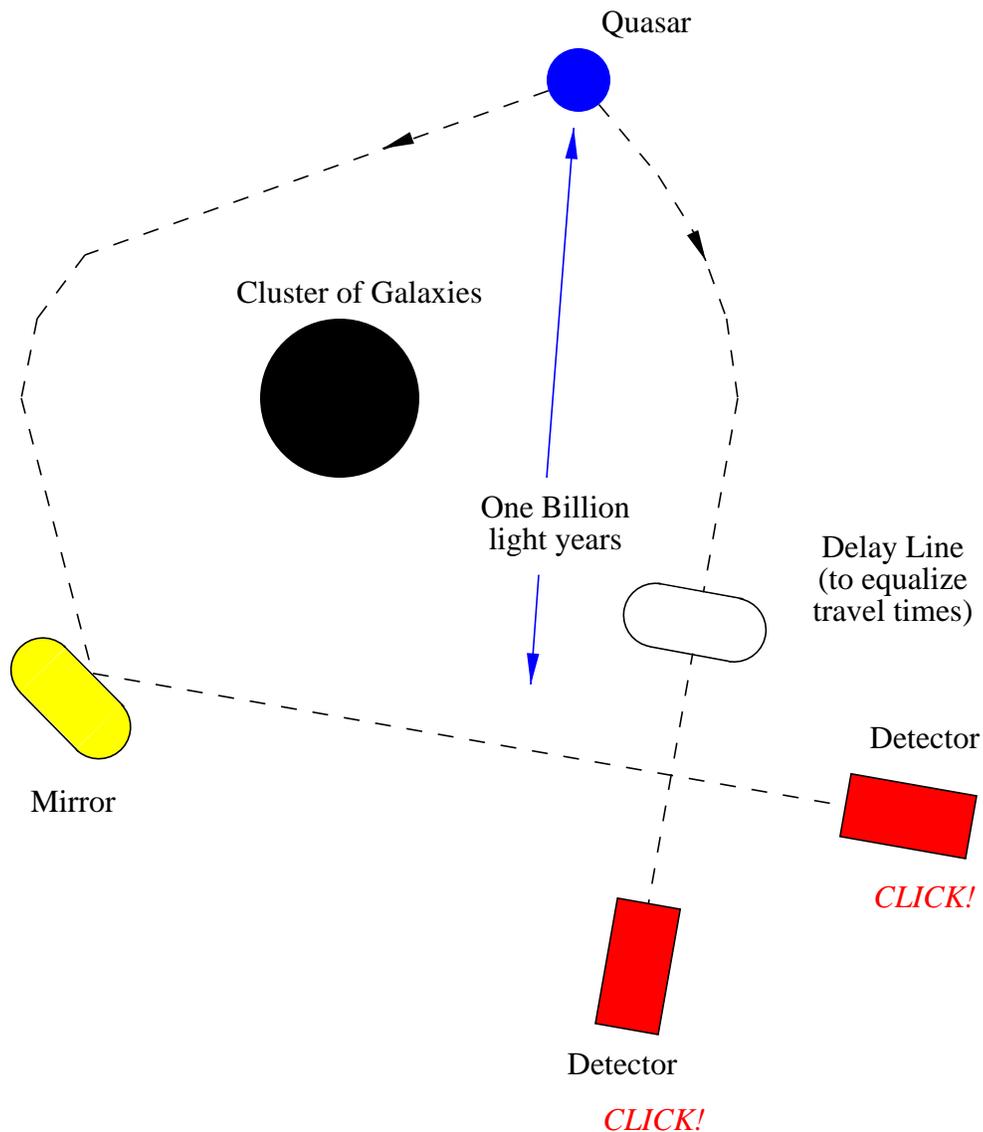


FIG. 3. Easily explicable *without* Quantum Mechanics

dash as a photon if you like: a photon that is “on its way,” toward us and our telescope here on Earth.

The two routes taken by our “photon-dashes” are not exactly equal in length. So the photons, if emitted at the same moment from the quasar, would arrive at Earth some weeks or months apart in time. That would not result in the amazing effect that Quantum Mechanics predicts. So, we put a Delay Line into one of the two paths, so as to equalize

the travel times. (That is why this version of the experiment has not been done yet, as we don't have good enough delay lines—in the laboratory versions of this same experiment, no delay lines are necessary, and the experiment *has* been done, successfully, many times.)

In our telescope, we have, cleverly, placed a Mirror, so as to force the two beams of light from the quasar (the two streams of photons) to cross each other, just before they are detected by the Detectors. (We arranged this so that we will be in a position to do “Part 2” of our experiment, which is coming up!)

The result of this, Part 1 of our experiment, is that as each photon arrives at its detector, the detector emits an audible CLICK, and we have detected its arrival!

Do we understand what is happening? Of course we do! Or rather, we foolishly think that we do! Photons are little bullets we think, and they certainly *seem* to dance to the tune that we have whistled!

(Hmmm! We do recall, don't we, that photons don't exist, in their own frame of reference? Well, that will not be directly relevant here. But, don't you forget it!)

Now for Part 2 of our experiment—the final part!

The only difference between our second version of the experiment (Figure 4) and the first, is that in the second version we have placed a beamsplitter where the two beams from the quasar cross each other. What is a beamsplitter? It is merely a thin piece of glass on which has been deposited a thin uniform coating of aluminum. That is exactly how a mirror is made, but in the present case the coating of aluminum is so thin that half the light passes through the coating (and through the glass) with the other half being reflected: in a true mirror, with a thicker coating of aluminum, *all* the light is reflected.

What is the result of our new experiment? Well, it depends on precisely where the beamsplitter is located. For some locations, the result is exactly as we got with no beamsplitter at all; we learn nothing new from that! However, for very slightly different locations, we get a dramatically different result: one detector goes off at twice the rate it fired previously, while the other detector never goes off at all!

Figure 4 shows the case of one of the two detectors responding (for a slightly different location, only the other detector would respond).

Our challenge now, of course, is to explain this result! One desires, naturally, to explain it in terms of our “oh-so successful” explanation of the first version of this experiment; namely, “photons moving through space at the speed of light!” But that explanation totally

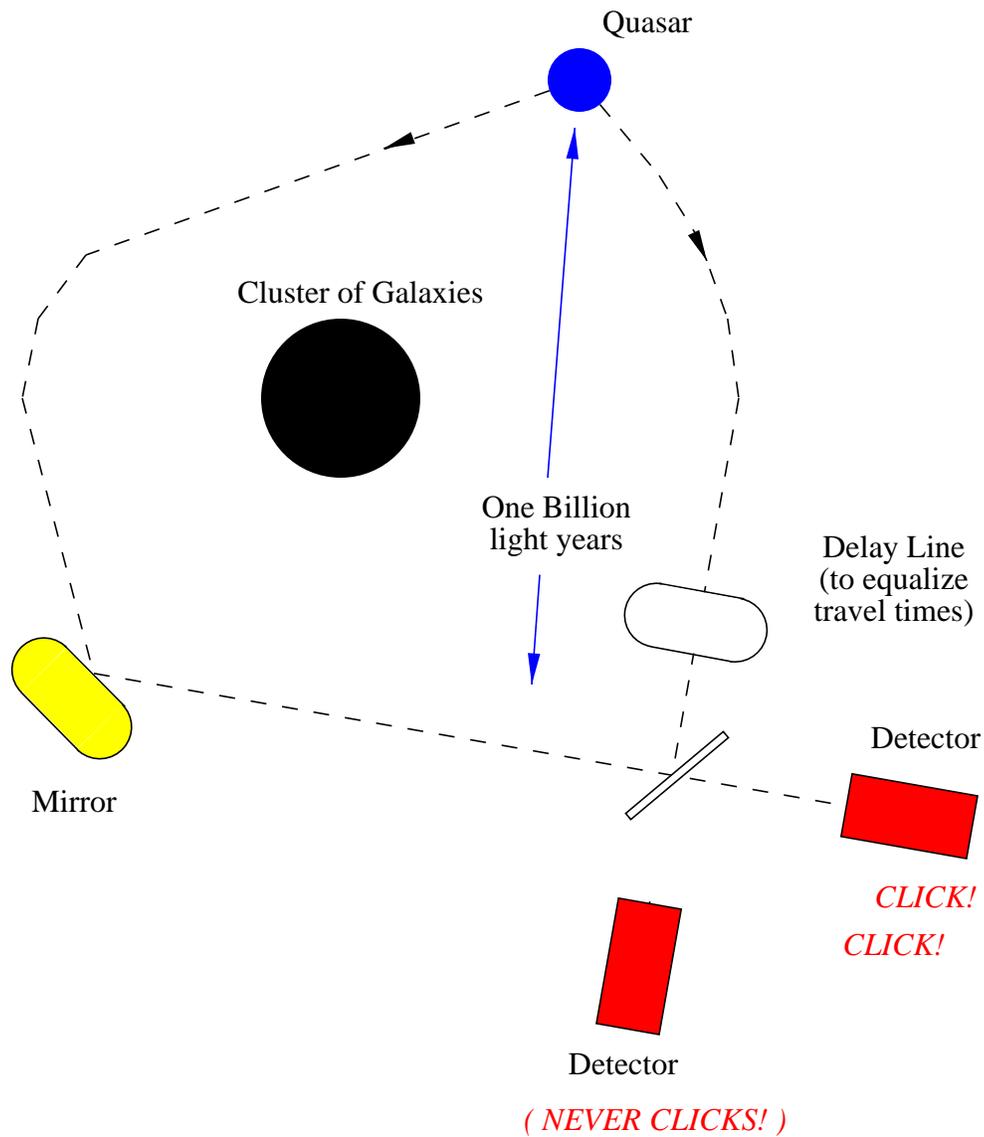


FIG. 4. Inexplicable *without* quantum mechanics

fails here, and no *other* explanation in terms of “photons moving at the speed of light” succeeds! Which surely means that our explanation of the first version of our experiment, beautifully as it *appeared* to work, was dead wrong!

Historically this kind of result was found, long ago, in laboratory experiments, and was initially explained as interference between the light arriving by one path, and the light arriving by the other path. That is why, for so very long, it was believed that light is a

wave—the notion that it was a particle (photon) was revived by Albert Einstein in 1905 (Newton had favored it), and was extremely difficult for physicists to accept. (When Thomas Young produced the evidence that light was a wave, and that Newton was wrong, physicists had found *that* extremely difficult to accept.)

Waves? In our version of the experiment, there is no question of waves, because the brightness of the two beams is so low that only one photon at a time could be in our detector apparatus! Forget waves!

Look at our last figure again. Stick your hand in either one of the two beams coming from the quasar. Immediately BOTH detectors start going off!

Remember that the title of this long section of this paper is “Quantum Mechanics.” Quantum Mechanics successfully *predicted* this result for our experiment.

(Similar experiments with electrons, and even with whole atoms, have exactly the same result. There are no “atoms” that are “out there,” any more than there are photons.)

What are we to make of this astonishingly simple experimental result, in terms of our understanding of the Universe?

1) I did not labor at attempts to explain our seemingly bizarre experimental result in “conventional” terms. I have no patience for that. It is a complete waste of time. It *does not* work.

2) Our result, I have just described as “*seemingly* bizarre,” because in fact it is *not* bizarre *at all*. Remember: our result was PREDICTED by quantum mechanics! It is the *expected* result, from the most successful theory, ever, in the entire history of physics. Any attempt to “get around it,” is a fool’s errand. I certainly will not waste your time on fool’s errands!

3) Remember that, although the fact that it is so is not widely known, quantum mechanics is not mysterious at all:<sup>2</sup> it follows, as a logical and necessary consequence, from only two simple facts: that measurements (e.g. temperature) have the character of human-invented numbers; and that simple symmetries exist. [An example of the latter is: if you do an experiment today, and then you repeat the experiment tomorrow, under exactly the same conditions, you will get the same result. That is called “symmetry under translation through time.” (It holds, but on average, even for quantum mechanics.) The same is true for translation through space, and also for rotations in space.]

Those symmetries are why your waking world is different from your dream world, where the symmetries do *not* apply (and so you can sometimes fly, which is fun).

We do not know *why* those symmetries hold. The best guess is that they do NOT generally hold, but that 13.7 billion years ago, exponential expansion of the Universe led to life appearing and then evolving—but only in a locally *smooth* patch, in a vastly larger chaotic universe: a patch that we are located in, a comparatively small region in which stability is possible. (There is no doubt that that the early exponential expansion did occur—otherwise the famous 3-degree cosmic background radiation would not be so uniform.)

Our final conclusion is that measurements are not “of” anything at all—they simply appear in your mind. Sounds radical? Well, sorry! It is *not* radical at all! This result has been known since the discovery of quantum mechanics, and it has routinely and repeatedly appeared in physics news: “Measurements Are the Only Reality, Say Quantum Tests<sup>3</sup>.”

Surely the time has come to acknowledge this fact!

## X. WHERE DOES ONE GO FROM HERE?

I have suggested that William Rowan Hamilton was the most brilliant physicist who ever lived. Really, deeply, stupid—yes!—but, nonetheless, the most brilliant physicist who ever lived.

But Hamilton was not the most *successful* physicist who ever lived: the most successful physicist who ever lived was Galileo Galilei.

For Galileo successfully convinced the world—the man-in-the-street—that the Earth was not the center of the Universe; that the Sun was the center of the Universe. Of course he was wrong about that, but that is not the point: the point is, he got people to believe—really to believe—the impossible: that the seeming solid Earth beneath our feet is moving, and moving at 30 kilometers per second!

Now, me, I would like to emulate<sup>4</sup> Galileo. That is the reason I wrote this account! I would like to bring everyman to really believe *what we already know* is the truth: there is no actually existing Universe out there: it is all in your mind. I hope that I have accomplished that!

That is the end of the story as far as physics is concerned. But, it is not the end of the story for you, or for me. In physics, there is no such thing as consciousness. Yet here we are, left with just our own individual consciousnesses—consciousness being the *only* thing that is real!

What *you* decide this means is up to *you*. There are no facts—only opinions—from this point on. All that *I* can do, is to tell you *my* opinion. That is not physics; that is not *science*; that is nothing but *opinion*. Agree, or disagree, as you wish; I cannot say that you are wrong if you do not agree with me.

My opinion is, that the conclusion that my *own* consciousness is all that there is, is unacceptable. I find in my consciousness experiences obtruding. If all that there is, is mind—and we have seen that that is so—those experiences must be manifestations of a mind. My mind receives them; does my mind also generate them? *If so, YOU are nothing but an experience that is generated by my mind—you are only my dream.* That is what I cannot; what I will not; accept!

## XI. MY CONCLUSION

I conclude that my consciousness can only be a tiny component of a greater Consciousness.

“Perhaps you adhere to a religion that attributes your existence, and that of the world, to a God, where a God is a mind that is vastly more capable than your ... *our* ... *own*.”

Darby awoke. It had, indeed, all been a dream.

## ACKNOWLEDGMENTS

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<sup>1</sup> R. C. Henry, “Quantum Mechanics Made Transparent,” *Amer. J. Physics* **58** (11), 1087 (1990).

<sup>2</sup> M. Shapiro, “Derivation of the relativistic “proper-time” quantum evolution equations from canonical invariance,” *J. Phys. A: Math. Theor.* **41**, 29 (2008) 175303 (9pp).

<sup>3</sup> J. Glanz, “Measurements Are the Only Reality, Say Quantum Tests,” *Science*, 70, 1439 (1995).

<sup>4</sup> R. C. Henry, “The mental universe,” *Nature* **436**, 29 (2005); R. C. Henry, “The real scandal of quantum mechanics,” *Amer. J. Physics* **77** (10), 869 (2009).