<u>m = E and Algebra Rules the Universe !</u>

Let's see how Einstein's Famous Equation — the one that tells us that ...

$$E = m\,c^2$$

(← *the key* to Nuclear Energy *!*)

… *emerges* from a slight — **but rather strange *!*** — **4D** extension of **…**

The 2D Pythagorean Theorem: $(the\ Hypotenuse)^2 = (side\ 1)^2 + (side\ 2)^2$

Set up **two 3D** reference frames: **Yours** (stationary) and "**the other**" **moving** along your x direction at constant speed v. Suppose a person **moving *with*** that frame snaps her fingers **twice:** **once** when her watch reads τ; **again** when it reads $\tau + d\tau$

The distance dx **you** see finger-snapper go, in time dt by **your** clock, is $dx = v\,dt$

  Albert Einstein *asserts* that between **YOUR frame** x, y, z [at **your** time t] ,
   and **HER moving frame** α, β, γ [at **her** time τ] , this **4D** *rule* holds true :

$$+\,d\alpha^2 + d\beta^2 + d\gamma^2 - d\tau^2 = +\,dx^2 + dy^2 + dz^2 - dt^2$$

 <u>Minus signs</u> for **TIME** *!* Her two fingersnaps**?** **Einstein:** $-d\tau^2 = +dx^2 - dt^2$

That is, $d\tau^2 = dt^2 - dx^2$.   Well! *If that is so,* then her $d\tau$ is **less** than your dt :

as finger-snapper *moves:* *HER* clock advances **more slowly** than does *your* clock **!**

[**not** *noticed !* ∴ just a **TINY** effect**:** $\frac{dt}{d\tau}$ *can only* be ***slightly*** > 1, if v is small]

<u>The result</u>: ➔ *An **algebraic** prediction* ➔ $d\tau^2 = dt^2 - v^2 dt^2 = (1 - v^2)\,dt^2$

which is **bizarre** for it **absurdly** claims that **velocities v** can **never** be greater than **1***!*

But! the speed of light, c, = **1** light-year per year… **and <u>EXPERIMENT</u>** *does* reveal that we ***cannot*** accelerate *anything* to *any $v > 1$!* So! **Our oddball 4D extension** of **Pythagoras** has unveiled an **unintuitive** and **unexpected** feature of our universe.

  So: human algebra rules the universe !   **Here is additional proof of that:**

Newton (and his followers) ***had*** discovered conservation of **momentum**: mv

 and had discovered conservation of **kinetic energy**: $\frac{1}{2}mv^2$

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But! **Einstein's IDEA** reveals both of these to be **incomplete**, in *two easy* steps:

First step:

$$d\tau^2 = (1 - v^2)\, dt^2 \quad \text{and so} \quad \frac{dt}{d\tau} = \frac{1}{\sqrt{1-v^2}} = (1 - v^2)^{-\frac{1}{2}} = 1 + \frac{1}{2}v^2 + \frac{3}{8}v^4 + \cdots$$

*A **cool** Newtonian series, **for we know*** $\frac{dt}{d\tau}$ can *only* be **a TINY bit *bigger*** than **1**
(if velocities are _much less_ than that of light).   [Hey! $\frac{1}{2}\ v^2$? **Hmmm!**]

Second step:

$$d\tau^2 = dt^2 - v^2 dt^2 \quad \text{and so} \quad \left(\frac{d\tau}{d\tau}\right)^2 = \left(\frac{dt}{d\tau}\right)^2 - v^2\left(\frac{dt}{d\tau}\right)^2 \quad \text{or} \quad 1 = \frac{1}{1-v^2} - \frac{v^2}{1-v^2}$$

If finger-snapper's mass is **m** then: $m^2 = \left(\frac{m}{\sqrt{1-v^2}}\right)^2 - \left(\frac{mv}{\sqrt{1-v^2}}\right)^2 \;\equiv\; E^2 - p^2$

$$\boxed{\begin{array}{c} p = \dfrac{mv}{\sqrt{1 - v^2}} \quad \cong\; mv \qquad (\text{ if } v \ll 1\,) * \\[2em] E = \dfrac{m}{\sqrt{1 - v^2}} = m + \dfrac{1}{2}mv^2 + \dfrac{3}{8}mv^4 + \cdots \quad \cong\; m + \dfrac{1}{2}mv^2 \end{array}}$$

* even if "**the other**" goes **60,000 miles per hour, *v* is *STILL* only 0.000089, ≪ 1**

If she is **STATIONARY** $(v = 0)$**?** Yes, her **momentum** $p = 0$, **BUT** her **energy**

$$\boxed{m = E}$$

… the equation that —with 40 years of engineering—led us to the Atomic Bomb.

That is by far the **most fundamental physics** that has **ever** been discovered!

Units? Instead of $c = 1$, **dumbbells** say: $c = \mathbf{1.8 \times 10^{12}}$ **furlongs per fortnight**

IF you **DO NOT** take $c = 1$ (← **NO** units!) **you MUST** replace v with v/c : *OK,* $\boxed{E = m\,c^2}$

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We have learned that **m = E**. ***In practice***, what ***mass = Energy***   **means** is this:

$$n + {}^{235}U \rightarrow {}^{236}U \rightarrow {}^{92}Kr + {}^{141}Ba + [\ E = [m_U - (m_{Kr} + m_{Ba})] \times c^2\ ] + 3\ n$$

In his 1905 $E = mc^2$ paper, Einstein noted that "relativity might be put to the test" by study of "certain radioactive salts." The equation above shows what was immediately found: the identification of a nuclear process that **would release** *some of the energy* that's in mass, in certain specific circumstances. We see above: one neutron *in*—and then: ***three*** neutrons *out*!   *A chain-reaction:* **Cogito,** Ergo **Boom**!

Why SO MUCH energy out? Hey: it is only 'much' in comparison with how **LITTLE** *kinetic* energy we find, *looking around us:* all matter moves **so damned slowly**, compared with $c = 1$, that there is almost **NO** kinetic energy in the world ….

[**Oops! Correction!** almost **ALL** of your body's mass is *actually* **kinetic** energy: *not* **mass**! For you are made of protons and neutrons, which in turn are made from up-quarks and down-quarks, which are not much more massive than are electrons, and, those quarks are **tightly** bound together by the exchange of … *massless* gluons! When you weigh yourself on a bathroom scale, almost ALL of that embarrassingly big number comes from … the **kinetic** energy of your **massless gluons**!]

Now please ask yourself: ***What does finger-snapper think about all this? She*** says, "***I*** am **NOT** *moving*, it is **YOU** who are moving—**and so**, time slows down for **YOU**, *not* for me!" That is a reason so many physicists found it difficult to accept relativity (and why some fail to grasp it even today). **If** finger-snapper reverses direction, and comes to you, *she* arrives younger. **But if**, instead, *you* go to *her* at a constant speed, *you* age less than she does. **[Theoretical physicists? *Hey—all of them* are *just kids*** who, as they grew up, discovered that they were whizzes at **mathematics**, and so they succeeded in becoming Professors! Apart from that, many of them are no smarter than are the rest of us. Which means that there have been, and I am sure that there still are, a number of *productive* theoretical physicists who simply *do not understand* relativity (and yes—I could give specific examples were I cruel). **]**

Mathematics!   *Me?* I *do* find equations *a bit of a strain !* But **you** (dear reader) *no longer **need*** equations, do you? For *I do expect* that I *have you*, by now, **trained:** that I have **now established in you *faith*** that if I report a mathematical result, you'll find it possible to accept it, *without* me, lengthily, and laboriously, spelling out the long, tedious, and *unenlightening*, **steps** of the mathematical processes for arriving at that result. I surely do hope so! (I bet that I've even managed to *slip something **past***

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*you **once***, already*!* that Newtonian series! It is *perfectly easy* math (well, **easy *once*** *Isaac **had developed it***, of course!) **but**, believe me — it is long, and it is boring: for **I know,** because *I've been through it:* through each and every [boring but easy] step.)

The *wonderful* **Sir Isaac Newton** was baffled by the physics that he had discovered! Sure, he found equations that **worked** superbly well, **but** he had *no idea **how*** or ***why*** they worked! For there was no mechanism! But **Pythagoras** had, incredibly, **solved** that problem long ago: **"Number is all things."** **Get it?** **If** you have *really* absorbed my first two pages in detail, you **do** get it: *there is no mechanism*. There *can be* no mechanism: the universe is **mental:** it is **mathematical**, and that is *all there is to it!*

Let me give you an example of a theoretical physicist who really **didn't** understand physics: Albert Einstein. (And I already gave you Newton!)

A physicist who at least understood *astronomy* was Galileo. I regard him as greater, in a way, even than Pythagoras, simply because old Pythagoras, unfortunately, hid his light under a bushel, and so the closeted mathcentric religion that he founded died out after a couple of hundred years (can we revive it today?—but uncloseted? let *all* the public ***know?***) **In contrast**, Galileo **bravely published** (*so*, Galileo spent the final years of his life *under house arrest !*) his Dialogue Concerning the Two Chief World Systems—**AND**, *amazingly*, **Galileo convinced the world:** that **Earth ROTATES** ! It drew ***ridicule*** to come out in public with that, ***then***, but ***today ?*** It is ***believed*** **by all**!

When quantum mechanics was discovered, Einstein **contributed mightily to it**, but in the end, *not* understanding, Einstein fell on the losing side. He participated in famous debates with Neils Bohr over the nature of quantum mechanics: Bohr, who understood physics, won every battle, but (unfortunately) **Einstein won the public war**. He **won** because of his **personality**, aided by the difficulty almost everyone had (and still has) at fully grasping quantum mechanics. Just like Newton, Einstein **accomplished wonders** without ever completely understanding what his own work meant. Sadly, almost all, today, are **stuck** with Einstein's view that the world is real.

Einstein wonderfully **explained gravitation**: as *curved spacetime*—and, *using* Einstein's explanation, Karl Schwarzschild *predicted* **black holes!** The **Gaussian Curvature of Spacetime** for **black holes** is ***zero*** (Henry 2000, ApJ **535**, 350) **but**— some components of the Riemann tensor are *non*-zero: ***no*** escape from black holes!

Let me deal with **quantum mechanics** right now, since it is so simple. The American mathematician **Emmy Noether** made the most important discovery **ever** regarding physics: she discovered **WHY** energy and momentum are **conserved**. It is

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because simple **symmetries** are present in our universe. [*Why* they *are* present, we do not know: except that, if they were NOT present, we could not *exist* to *ASK* why!] If you do an experiment and then repeat it the next day you get the same result: **Emmy showed** that *that* results in conservation of **energy**. If you do an experiment and then move it sideways and repeat it, you get the same result: **Emmy showed** that *that* results in conservation of **momentum**. If you do an experiment and then rotate the apparatus by some angle, and repeat it, you get the same result rotated: **Emmy showed** that *that* results in conservation of **angular-momentum**. And, those symmetries **being present**, **quantum mechanics follows**, simply by **mathematical necessity.** There is **no mystery at all!** (Hey: you want to plow through it? Just see Henry 1990, American Journal of Physics, **58**, 1087; and also, be sure to read Shapiro 2008, J. Phys. A: Math. Theor. **41**, 17, 175303). [And, **QM says: NO determinism!**]

One remarkable **exception** : if you do an experiment and then you do the **mirror-image** version of it, well, yes, you **do** get the same result (mirror-imaged of course), **but only** if your experiment involves the gravitational; or the electromagnetic; or the "strong" (nuclear) force: **BUT**, if your experiment involves the fourth, **"weak"**, **force** (which is responsible for the observed decay of free neutrons into a proton and an electron, plus an antineutrino) you get a *different* result! *So*, **a broken symmetry!** This **hints at** **why matter and anti-matter did not annihilate, leaving NOTHING?**

Quantum Mechanics (1925) was quickly discovered to make **absurd predictions**— *but: those predictions were verified by experiment !* QM seemed to say that light is *not* a wave—instead QM seemed to say that light is particles (dubbed "photons"). Yes, "photons" did *SEEM* **to be detected**: **clicks** from photomultiplier tubes!

But *more* **experiments** revealed light to be *nothing at all:* as we will now see, there are *nothing* but **measurements** (**numbers**): there's **no-thing** *being* measured. (Perhaps we need a *new word:* "**records ?** ", to replace "measurements.")   Here is a **crucial experiment:**

Send a beam of light into an interferometer, where—first—a tilted piece of glass *transmits* **half** of the light that impinges on it and *reflects* the *other half* to one side— then, the two resulting beams are made to *cross* each other at right angles. At the crossing point a *second* tilted glass beamsplitter is placed. From the second glass, light emerges in each of the expected two directions. And, if the beam is of *low* intensity, you see the light arrive at your two detectors in **bursts** (hence, "photons").

The two paths are **adjustable:** they can be set to be of unequal lengths.

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Maybe you've found that *half* the bursts out were reflected and *half* were transmitted? **Photons !** But, if you slightly change one path-length enough, ALL of the photons emerge on ONE of the two paths! *Interference* ∴ **Waves** *!* Conclusion: **There** *are* *no* **photons and there** *are no* **waves: there are only records!** Furthermore, these results are **unchanged** if your path-length adjustment *only takes place* AFTER you *know* that the light has already *passed* the first glass: *think about that one, folks !*

Those outcomes are **predicted** by **quantum mechanics: so, end of story!** Quantum mechanics clearly says (and **! experimental test shows !** — *yes indeed,* to our *great astonishment !*) that until the "photons" actually arrive … **their decision at the first beamsplitter is not yet made**. **Conclusion:** there **are NO** photons—there are only measurements—**records**. The concept of 'photon' is, while in many circumstances very useful indeed—only a crutch: **no photons exist**. Say **records**, not photons!

If there are no photons, there are no electrons, and there are no quarks—for there are no exceptions to quantum mechanics! All there are, are **records**. The entire universe does **not exist:** it is *entirely* in your mind. *And* the sky does *not* touch the ground at the horizon: *even though* it is **obvious to our senses that it surely** *must! Grow up!*

This *does* raise a **nasty** and **profound**—but unanswerable—question: **Who** qualifies as a (or as *the !*) **recorder** ? **Nothing will make the experiments go away!** The unavoidable conclusion from ALL of this is that what we call a universe **is NOT that**—it is a *construction*, built simply from the **recorder's** **observing experience.** In reality, what we call a universe: is entirely mental (Henry 2005, Nature **436**, 29) .

Now, look around you, and, of course, it all seems so real: oh yes, evolution has **made sure of that**, by (apparently, *only!*) working over aeons, for the survival of your ancestors so as to produce that wonderful ultimate product: **you!** But don't be fooled! Treat the world, tactically, as real of course, for YOUR OWN survival—but don't make a fool of yourself by believing the universe has any material existence: demonstrably it does not. YOU reconstruct the history of the universe, back to the Big Bang, simply by existing and going about your daily life. And what about G—d?

Logic limits God: when I was small, a girl (I did not know) confronted me with the question: "Can God do ANYTHING?" Flummoxed, I blurted "**yes**!" She then asked "Can God make a stone that is so heavy that not even *God* can lift it ? " Logic rules*!*

Summary: Pythagoras + 3 spacetime symmetries + 1 broken symmetry ➜ gives us.

Postscript: One huge remaining mystery is the DARK MATTER: *possibly* detectable in the UV.