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Relativity is a Two-Faced Janus
(Or: Does SRT live up to its name - Relativity)

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2nd Face:
SRT is a **classical** physical theory and as such deals with description of physical reality by numbers. The presumption used in any classical theory is that physical reality can be described by the numbers. From one side this presumption based on the believe that the physical reality is unique and from the other side on the fact that the numbers are unique. The merits of SRT are:

1. SRT introduced 4-dimensional supernumbers to describe moving objects.
2. SRT found 4-d metric tensor: before we knew only that the proper length of the straight line between the points A(x=0,y=0) and B(x, y) is sqrt(x2+y2). Now we know that the proper length of the straight line between the points A(t=0,x=0) and B(t,x) is sqrt(x2-c2t2) or proper time is sqrt(c2t2-x2).
3. According to the requirements of 4d description Einstein improved Newton's dynamics equation to the Relativistic Dynamics Equation.

These three are the big advantages and they represent the second face of Janus. There is no relativity here. We did not care in 3d geometry that different observers can use different 3d coordinate systems. In 4-d description we have the same option: not to care about other observers also. All physics with all "relativistic effects" can be described in just one 4-d coordinate system.

There is a little disadvantage: to manage the second face of Janus we have to be able to manage math on pretty high level. Let us elaborate a little.

Physical reality is unique in all its manifestations. Although the number of these manifestations can be uncountable each one is unique.

Example: physical point **P** on a physical plane (sheet of paper). This point can be described mathematically by two real numbers **x** and **y.** Each real number has its own math identity. We have a paradox: one physical identity (point **P**) is described by two math identities (x,y). But we should use only one math identity to describe a single physical identity. We have to deny math identities of the real numbers **x** and **y** and say that they together define some other but single math identity (2-dimentional supernumber).

If we solve this paradox (we have to develop a theory of supernumbers and use it), we will get Special Theory of Relativity. No postulates needed!

"Theory of Supernumbers" - where to get it? May be somebody already developed it and kept quiet about it? - Yes, Riemann did! He developed it to get his "n-Dimensional Geometry with Curvature".

Let us stop for a moment: - "Geometry"? Is Geometry mathematics? As the word "Geometry" sounds it is **Physical theory of unmoving physical objects. It is theoretical physics.**

But theoretical physics is an application of mathematics to the task of description of physical reality. What kind of math is used in Geometry? Nobody studied it separately from Geometry. The guess is: it is math theory of 2-dimensional and 3-dimensional supernumbers (Note: you can not use 4-d supernumbers in Geometry but if you want to have a physical theory of moving physical objects then 4-d supernumbers will be quite appropriate). What is Riemann's contribution to Geometry? He showed that if you have a 3-d sphere with some surface physical objects then to describe these objects instead of using 3-d supernumbers and Euclidean metric you could use 2-d supernumbers and some metric that reflects the curvature of the sphere.

Also: now we can raise a question if 3-d supernumbers with non-Euclidean metric will be more appropriate for the description of unmoving physical objects (curvature of 3-d space). What is Riemann's contribution to the Classical ElectroDynamics (CED)? Now we can use 4-d supernumbers with Lorentz metric for the description of moving physical objects (Einstein actually applied it in his SR)

We also can raise a question if 4-d supernumbers with more complicated 4-d metric will be more appropriate for the real physical world (curvature of 4-d space).

In CED we do not experiment with curvature at all. We just happy that SR is introduced for us 4-d supernumbers with Lorentz metric (and this is a big advantage, but this advantage is mathematical and in this respect is not questionable. If you will try to support or refute SR by the experiment - you will be supporting or refuting basic principles of CED, not SR). What is Riemann's contribution to mathematics? Among others he developed a math theory of **n**-d supernumbers with arbitrary metric (not n-dimensional geometry with curvature!).

Little bit more about supernumbers: What kind of supernumbers do we know? What is a vector or tensor? We have a wrong impression that it is the physical concepts. Even 3-dimensional vectors and tensors we perceive wrong. Example: velocity is a physical condition that can be described by 3-vector (or 4-vector, as SR requires). That means that vector is a math. Concept (special kind of supernumber). Remember usual expression: "velocity is a vector"? It is the same as one would say: "temperature is a real number". No! Temperature is a physical condition that can be described by a real number!

The math theory of supernumbers gives us:
1. Coordinates themselves together define the supernumber that called "point" which is independent variable. The point caries its identity through arbitrary (the reverse transformation should exist) transformations of coordinates (coordinates change but new coordinates describe the very same point).
2. Scalars (invariants) that defined by one real number -- they do not change with coordinate transformation. They are functions of point as well as all other types of supernumbers.
3. Vectors (tensors of the 1st rank) that defined by their **n** covariant components that transform according the law that becomes definite when the transformation of coordinates is given. Or they defined by their **n** contravariant components that transform according to another law that is also definite after the transformation of coordinates is given. You need to use the metric tensor to obtain contravariant components if you know covariant components and vise versa.
4. Tensors of any rank. The second rank tensor is defined by its **n2** covariant or contravariant (or mixed) components. To define a 3rd rank tensor we need **n3** real numbers and so on.

All these supernumbers preserve their identity after arbitrary transformation of coordinates. We call them mathematical objects (as well as their multitudes -- lines, triangles...). Actually the preservation of identity with respect to arbitrary coordinates transformation is the basic principle that is used to separate supernumbers (math objects) from anything else. The components of these supernumbers change in different coordinates. We call them math. Accessory. Only math objects can be used for description of physical objects in classical theory. In classical theoretical physics mathematical objects represent the exact boundary between mathematics and physics.

After we questioned what Riemann did for us, let us ask the question what Einstein did for us?

The Special Theory of Relativity is based upon 2 postulates:
1. The laws of physics are identical in all Inertial Reference Frames (IRF).
2. The speed of light in vacuum is the same in all IRF.

What does it mean "in all IRF"? It is fair to say: "after an arbitrary Lorentz transformation"; or we can add here: "after an arbitrary translation of coordinates." It looks almost the same criteria as arbitrary transformation of coordinates that was used by Riemann. What does it mean "The laws of physics are identical (actually Einstein used "in concordance")"? Is it only laws should be identical but not physical values, or both? It is not definite what it means. Let us better try to judge SR by its outcome.

Einstein introduced 4-d supernumbers and Lorentz metric in theoretical physics. His postulates look like not physical (they do not change physical laws) but mathematical requirements because they are correspond to the basic principle of mathematical Theory of supernumbers. The physical predictions we are still getting from

Maxwell's equations. Maxwell's equations equivalently can be written in 3-d or 4-d form. That means that their solutions in 3-d and 4-d forms also equivalent. The light in vacuum goes along a straight line that has zero proper length (consequence of Maxwell's equations). That is invariant and will be zero in any coordinates.

What about Lorentz transformations? Does it have any physical meaning? No, it just simplifies our mathematical work. Lorentz transformation is not a number (or supernumber) to represent some physical reality. It is just one from of arbitrary transformations. More important than Lorentz transformation is Lorentz metric tensor.

Suppose we wrote Maxwell's equations in usual 3-d form in coordinates **x, y, z** in Euclidean metric with **t** as some independent variable. Now we are looking for the possibility to rewrite Maxwell's equations in 4-d form that would be fully equivalent to the 3-d form (solutions are expected to be the same). If we take the same **t, x, y, z** as 4-d coordinates we still need to know a 4-d metric tensor to do the job; and we do not know if the task is possible at all. It appears that Lorentz metric tensor solves this problem. The Lorentz metric tensor is something phenomenal. It is unique and it is the mathematical object. In this respect it could've represented some physical reality. But any physical reality can be present or absent. In CED this tensor remains the same that means that this tensor belongs to mathematical apparatus that we use.
So far we've seen only math advantage that Einstein introduced in physics. What did he do for physics (meaning something that changes the experimental predictions of CED)? a) Any physical equation that is written in 4-d form with the use of Lorentz metric can be rewritten in 3-d form, but not any 3-d equation can be rewritten in 4-d form without actual changes to the equation. This happened with Newton's dynamics equation. To rewrite it in 4-d form the linear momentum m**v** has to be replaced with m**v**/sqrt(1-v2/c2). This way we are getting so called Relativistic Dynamics Equation with spectacular confirmation by the experiments with elementary particles. This is the grate physical achievement of SR and a good lesson for anybody who likes to develop a new physical theory: any physical theory should be "relativistically invariant" (written originally in 4-d form and then reduced to 3-d form.)

b) Mathematical improvements often allow obtaining solutions that were not obtained before due to math complexity. Such is the following task:

Suppose we have a physical clock that moves in **x** direction with velocity **v**. In coordinates (**t,x)** the position of the clock will be **x=vt.** The clock "ticks" every second. If the first tick was at **t=0, x=0** then at what **t** and **x** will be the second tick?

We can expect to solve this problem directly from Maxwell's equations and Relativistic dynamics equation. To do that we have to have exact physical model of the clock. If we take proton and electron rotating around it as a clock's model we have to include radiation in our model. This task looks too complicated.

The simpler way is: We have two events with coordinates (0,0) and (t,x=vt). Since these events are connected with a straight line we can find the proper distance between these events t*sqrt(1-v2/c2). This proper distance is a scalar and can represent some physical condition of the clock (t can not represent anything physical since it is one of the coordinates of the second event -- it is math. accessory.) Clearly we can write: 1= t*sqrt(1-v2/c2). Then: t= 1/sqrt(1-v2/c2). We got so called "time dilation".

There is no any doubt in my mind that if we would find a good physical model for the clock and solved Maxwell's and Dynamics equations we would get the same result. The same logic applies to so called "length contraction".

At least we have to know a "Riemann's n-dimensional geometry" which in fact is a mathematical theory of n-dimensional supernumbers to understand the second face. This is why the second face looks not so attractive and normally hides behind the first face. But the second face is a real thing while the first face is a fake.

1st Face:
For better understanding I composed a little parody:

PARODY ON THEORY OF RELATIVITY

3-dimensional geometry perfectly describes not moving physical objects. In particular it is simple if the objects are flat: we can use just 2 coordinates x and y.

Suppose some unit length stick is resting flat in the middle of the perfectly flat desert. If we direct y-axis to the North then we can describe the stick by 2 numbers: x=x1, y=y1. We have: x12+y12=1, If V is the angle between stick and x-axis, then: V=arctg(x2/x1). We can use another 2 numbers to describe the stick: x1, V.

There are plenty of observers going across the desert in different directions. When one of them stumbles upon the stick and wants to describe it, one has natural right to put y-axis along the line he approached to the stick. Then one finds x1 and V.

The "Theory of Relativity" will be like that: although everybody approached the very same physical stick, their measurements x1 do not have to be the same -- they, actually, will depend on the line of approach. Besides x1 they will measure V and can find invariant length: x1/(cosV) which will be 1 for all observers. The conclusion is: the measurement x1(and we claim that it has a physical meaning) will be relative to the observer.

Is this "Theory" true? It is perfectly correct! The thing is: it is unnecessary (we know that by experience: geometry works all right without this kind of "Theory of Relativity"). In Einstein's 4d case we can say the same if we know 4d supernumbers upfront. Einstein introduced 4d supernumbers start on without appealing to mathematics. This makes the first Janus face so attractive.

Let us take an example: the strait line between points A(0,0) and B(t,x). Suppose ct is greater than x. This line is a physical reality (trip of a physical clock) can be described by a supernumber (t,x). We can not drop **t** or **x** from this supernumber. **t** and **x** are the components of the supernumber and can not have any physical meaning taken separately. The first face of Janus based on attributing the physical meaning to t separately (it is not good to call t time, it is time coordinate). To support that Einstein introduced physical frame in whole space and put resting physical clocks in every point of space. Relevant to our example will be the second clock making a strait line between A(0,0) and C(t,0). The proper time of the first line is invariant: sqrt(t2-x2/c2) and has physical meaning. The proper time of the second line is **t** and also invariant. We have two supernumbers: (t,x) for the first line and (t,0) for the second. This does not allow us to attribute a physical meaning to time coordinate **t** separately.

The same logic works with "length" as above with "time".

The List of Relative things in Einstein's Relativity:
1. Time (time component of some proper distance)
2. Length (terrestrial component of some proper distance)
3. Energy (time component of 4-linear momentum)
4. 3-linear momentum.
5. The same with angular momentum.
6. Electric Field (part of 4-tensor of Electromagnetic Field)
7. Magnetic Field (the same)

After we know the "facial" structure of SRT we would want to get rid of the first face. But the problem is: the name "Relativity" is connected only to the first face. With the first face we have to throw away the name. (And by the way: nonclassical aureole of SRT originates only from the first face).