A Background Independent Space-Time Model

Peter Eklind

Abstract: All modern physics is based on one assumption. An assumption that no one has any evidence, other than gut feeling, that it is true. The assumption is that space-time is fundamental. Space is required in order for matter to exist. But, what if it is the other way around – what if matter is the origin of space-time? This paper argues that using the assumption, that matter is fundamental to space as a starting point, would open up for solution of a lot of the unanswered questions in physics today.

Keywords: Space-time, Relativity, Standard Model, Theory of Everything

Introduction

This paper is based on questioning two established models in physics.

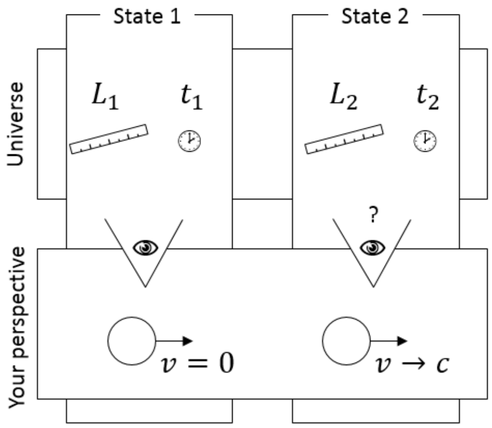
<u>1. Electromagnetism is transmitted via particles, photons, travelling at a speed of 300 000 km/s.</u>

Your first reaction to this might well be that this is a perspective that is too simplified. One has to understand the full implications of Quantum Mechanics to understand this process. True. But hold that thought, I will come back to that. First, let's just try to isolate the photon-as-a-particle model.

First, this particle doesn't have a mass. That alone could be enough to question the hypothesis – in the contexts that we are familiar with, "no mass" equals "don't exist". Second, the particle analogy doesn't give the full picture. It could change identity from particle to wave (the particle-wave dualism) dependent on the situation and way of measure. Third, it is impossible to indicate other than in its start and end position – all measures in between will "destroy" it. Forth, and even stranger, although we can prove that the photon cannot carry hidden information, it seems to be able to coordinate itself with another photon, if created from the same photon pair, immediate and over any distance (known as the EPR paradox). Fifth, accepting all that and still consider it a particle it might not be hard to accept that it has a one-speed-only.

But, considering a photon speed restricted, makes more sense from an external perspective than from the perspective of the particle itself. Assuming that you are a particle, approaching the speed of light – what would happen? According to Hendrik Lorentz' Length Contraction everything will get smaller relative to you. Approaching the speed of light all distances will be so small that they disappear – high relative speeds will make the universe shrink (at least in the direction that you are travelling).

How would I view the universe if my relative speed approaches "c" (i.e. my view of State 2)



$$L_2 = \lim_{v \to c} L_1 \sqrt{1 - \frac{v^2}{c^2}} = 0$$

$$t_2 = \lim_{v \to c} t_1 \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \infty$$

$L_2 \to 0$ Interpreted as if the universe is infinitesimal small – there are no distances

$t_2 \to \infty$ Interpreted as if my time stands still relative the rest of the universe

$\Rightarrow$ If there are no distances and no time elapses for me, it is more accurate to say that I "jump" in space-time rather than "travel". Even though I'm dependent on the way I'm never "there".

There is no theoretical speed limit restricting travels to distance places in the universe in short time (short from your perspective that is). Rather every distance will turn out to be too short to really get up to speed. From the light's perspective it will hence exist in an infinitely small universe. Time will seem to have taken a leap forward, corresponding to the distance when in rest, and then stopped. From the perspective of light, "travelling" is more like placing a pinpoint on a photo – it won't take longer to reach things in the foreground than in the background.

The problem with the model of forces transmitted via particles is hence not that these particles don't behave like macro scale particles. The problem is that they are supposed to travel, and during the way interact with other particles, and that this should occur without any time elapsing, from their perspective.

<u>2. There is a universal continuous space-time fundamental to everything else.</u>
Intuitively we tend to view time and space in the universe as a scaled up version of the smooth, continuous and perfectly Euclidean space-time that surrounds us in every day life. However, time and space don't behave in this way when we are putting them to the test. So, what is done in physics – and now I am generalizing – is that the intuitive space-time is considered fundamental, and adjustments and correcting factors are added so it could fit with other models (such as Relativity or the Standard Model). This space-time is basically universal, continuous and fundamental to everything else.

There is a reason why so few are trying to seriously answer the question what space-time really is – it seems to immediately turn into a philosophical question. Still, it should be possible to extract at least a couple of possible options regarding the fundamental properties of space-time:

- Space-time has to be either a single entity, or a composite of many parts

- Space-time is either fundamental, or a result of something else

To my knowledge there are no commonly accepted experiments or models proving that space-time should be a single entity fundamental to everything else. It is not sufficient that a mathematical model could describe the space-time – it is possible to mathematically express composite space-times as one universal space-time by expressing it as non-Euclidean. Various forces will then be shaping the structure and acting as correction variables to express local variations.

By first impression, space is seemingly Euclidean. However, near large masses the space curves. To compensate for that, a force "gravity" that could change the shape of space-time is introduced. Still, it is too weak to explain why large structures such as galaxies don't fall apart – so you have to introduce a "dark matter" to take care of that. Still, it can't explain space inflation so a "dark energy" has to be introduced as well. The model of gravity only works on a macro scale, and seem incompatible with other forces (electromagnetic, weak and strong forces). To solve this you need String theory, with strings, described as "1-dimensional slices of a 2-dimensional membrane vibrating in 11-dimensional space". There are several related string theory models, of which no one seems to be generally applicable.

The new hypothesis: The alternative space-time model

Based on the weaknesses in the established models above, this paper introduces a new hypothesis, based on two things:

- The space-time that we experience in the universe is a composite of many small space-times. Every particle is the origin of an individual space-time.

- Electromagnetism (and forces in general) is an instant exchange of attributes between two particles. There are no counterparts in "reality" corresponding to the models of energy particles and fields.

This would imply that particles are the prerequisite for space. Without particles there would be no space and time. The exchange of attributes between particles would be the glue that creates the structure of the space-time we know from a macro perspective.

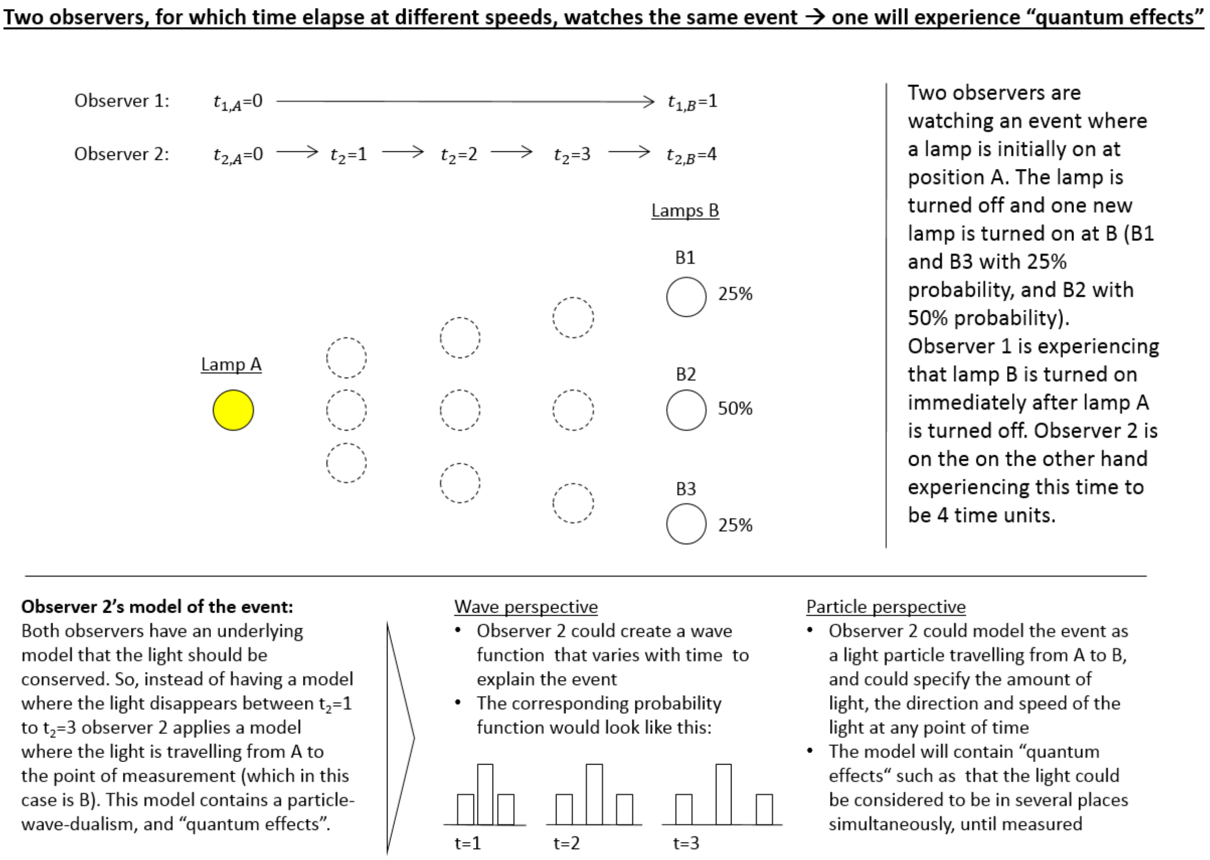
At first appearance this hypothesis might not seem helpful at all. A weird, strange new universe replaces something that is fairly intuitive. But, accepting a counterintuitive universe, other things will start to make sense...

Consequences of the alternative space-time model

<u>Light</u>

The theories of Relativity, Quantum Mechanics and the Standard Model have everything that is needed to explain what light is, and how it behaves. Still, the models' descriptions are complex, counter-intuitive and contain paradoxes. There are three possible reasons for this: (1) the complexity and paradoxes are part of nature, (2) the theories are not complete – there exists better and more comprehensive models, (3) there is something wrong with the underlying assumptions of these theories (although right in themselves) that makes us interpret them in a way that creates the complexity and paradoxes. The alternative space-time model is primarily targeting the third option. The underlying assumptions on what space-time and forces really are, are assumed to create a weak platform for the above-mentioned theories.

The alternative space-time model will necessarily generate the kind of paradoxes and strange behaviour that we see in light and Quantum Mechanics, if we interpret it from the view of a common global space-time. It is however not a sufficient proof, there might be other completely different models that also generates this kind of effects.



The alternative space-time model also makes more sense when it comes to the paradoxes from the first hypothesis. Light (and all elementary bosons) would be interpreted as an instant exchange of attributes (energy levels) between particles (fermions). The model for the exchange does not include force-carrying particles, so there won't be any problems with massless particles or speed restrictions. It is obvious that measurement or indication of light between origin and end is not possible. It would be possible to describe the exchange as a particle-wave dualism, from an observer's perspective. Even the ERP paradox makes more sense, when realizing that no time elapses from start to end (from the particles' point of view).

To summarize, from our perspective light seem to behave odd for one reason – it does not exist between its origin and arrival. So, a lot of complexity in physics is based on what light does, and how it behaves, during a time period that is zero from the perspective of light.

<u>Relativity</u>

The strangest thing with the Theory of Relativity is probably the relativity in itself. If we are living in a common space-time, how could seemingly fundamental things such as size, mass and time be relative? It is one thing to say that they depend on your (external) point of view, but the Theory of Relativity goes one step further and proclaims that there is no "truth".

If we apply the alternative space-time model, the underlying relativity will disappear. Then everyone has their own space-time. If another space-time is moving compared to yours, you will experience “relativity effects”. But the reason is that you are not using the same watch, scale or yardstick. The effects will however be the same. I assume that it corresponds to rewriting the Theory of Relativity in local coordinates – this will make it background independent (not relying on a general space-time), but it will give the same physical results.

Mass

In modern physics, mass occurs in different contexts: as part of energy-mass conservation, as generation of inertia when subject to accelerations, and in gravity. In all perspectives the value of the mass is the same, but there is no underlying mechanism explaining why. Mass is more or less a given parameter. The closest thing to an explanation is the higgs mechanism in electroweak theory, which is required to explain masses in the Standard Model.

With the alternative space-time model there is also an intuitive explanation. Mass would be the result of particles interacting with other particles. All particles (at rest) are supposed to interact with each other all the time, resulting in their (rest) mass. Mass is hence not an intrinsic property of particles, rather something given by the context and the available energy. Particles that have higher energy levels can interact with a higher frequency, which would result in higher mass. The amount of energy exchanged should be proportional to the mass, which we already know that it is, from energy-mass conservation (E=mc2). It also explains how high energy is anchoring the particle to everything surrounding it, creating the inertia, and the gravity’s ability to attract.

A consequence of the alternative space-time model is that all particles should have a mass and that all particles with masses should be able to exchange energy with each other. This would be fundamental in understanding what space is…

Space

In modern physics space-time is more or less taken for granted. It is fundamental for the whole universe, and in multiverse theories also for many other universes. There is however a problem with this – matter is at the same time both connected and not connected to the space-time.

First, matter and space are clearly connected, as seen in gravity. Matter can change the shape of space, curving it around high density of matter. From a macroscopic point of view the “concentration of space” is higher where there are more matter.

On the other hand, there is nothing that connects particles and space. In mathematics a point in space will carry the properties of its location – in Quantum Mechanics such properties cannot exist, referred to as the Uncertainty Principle. There is no way for a particle to “know” where in space it is supposed to be, before it is measured.

With the alternative space-time model, space would be a result of matter, rather than a precondition for matter. Space and matter will then obviously be connected. However, the alternative space-time model would also require an uncertainty principle. To indicate or measure a particle you would have to establish a connection to that particle. In order to do that the particle needs to abandon one existing connection, thereby changing its position in space and its energy level.

So, how does two particles, infinitesimal small, located anywhere in the universe, without agreeing in advance, collide? And why don't they collide e.g. in the atom? More on that shortly…

Distance
In the relativistic world the length of a distance is in the eye of the beholder. Two particles could be considered either close or far apart depending on your speed relative to them. There is no such thing as an objective distance. However, their position relative to each other never changes. If we consider two particles, A and B, on a line, we might not agree on the distance between them, though we will agree on if A is to the left or right of B. Space dimensions could obviously be broken down into more fundamental parts.

Breaking down the space dimensions into relative position and distance would be fundamental in the alternative space-time model. To understand distance we first have to understand what movement is on a micro scale. We have previously shown that if something moves with the speed of "c" it will never exist anywhere between its start and end position, and it is hence more accurate to consider it jumping. Particles (i.e. fermions) have masses and interact with other particles by exchanging attributes and will therefore move at speeds less than "c". This does however not mean that they are moving in a smooth constant motion as we are used to in the macro world. It would be more accurate to consider them jumping between the moments of interaction. It would be like a bus that is teleported between the bus stops.

In the alternative space-time model, particles can interact as if they are closely connected independently of distances. Distances wouldn't exist on a micro level. The space dimensions that we experience would hence consist of a relative position that exists on a micro level and distances that would only exist from a macro perspective.

Distance is also determined by the interaction between particles. The less likely a particle is to interact with a particle possible to interact with, the longer we experience the distance. Frequent interaction with the same particles (e.g. as in the core of an atom) makes them close. Particles that can interact ends up closer to each other, e.g. will particles with different charge becomes closer than particles with the same charge (that don't interact).

On a micro level the generated distance between particle A and B is proportional to the probability that A and B interacts. On a macro perspective the distance between A and B is proportional to the frequency to interact via all possible networks of connections.

It should be possible to use the wave function to calculate the probability of an interaction, from a macro perspective point of view. Although there is a problem that has to be accounted for – with the wave function you assume that there are particles to interact with everywhere. With the alternative space-time model you would have to accumulate all probabilities corresponding to the particles possible to interact with. It would be the relative position of the particles that would determine which ones are possible to interact with.

Gravity
In General Relativity, gravity is presented as a property of space, explaining how space-time can be curved. In quantized theories however, gravity is considered a force transmitted via virtual particles, gravitons. The problem with the latter model is that light too is effected by

gravity, interpreted as photons interacting with gravitons. If we, in the same way as before, views the process from the photon's point of view, it would exist in an infinitely short time. During that infinitely short time it should interact with gravitons also existing in infinitely short times. This model does not make sense.

With the alternative space-time model, gravity is an experience on a macro scale of how the space-time on a micro level is constituted. It is not a force in the same way as electromagnetism, weak and strong force, which are based on particles exchanging attributes. However, particles exchanging attributes makes them closer. Gravity would be the secondary effects of that interaction. If particle A exchanges energy with particle B and particle B exchanges energy with particle C, then particle A will be closer to B because of electromagnetism, but particle A will also be closer to particle C, and this is explained as gravity.

Einstein's theory of relativity assumes a continuous time-space. If there is no such thing as vacuum, I would assume that the strength of gravity would be higher between galaxies than the theory predicts. "Dark matter" could be the factor indicating this.

"Speed of light"

If I learned to master magic, and with that instantly teleported me from here to a place far away, you would experience that I travelled that path, with a speed, 'c', of approximately 300 000 km/s. But that speed is based on your experience, not a property of my behaviour. The same would be true for light, with the alternative space-time model. So, if the speed of light 'c' really isn't a property of light, what is it then?

To understand this, let's consider two close particles A and B, and two particles far apart C and D. Assume that each particle has their own time, divided into 10 discrete slots. If particle A transmits energy to particle B at timeA=1 it could receive at timeB=1, and particle B could send the energy back at timeB=2 receiving at A at timeA=2. Since particle C and D are far apart, the same interaction could be as follows: Particle C transmits energy to particle D at timeC=1, receiving at timeD=1, and particle D could send the energy back at timeD=2, however this time it would receive at particle D at e.g. timeD=8. The difference timeD=8 and timeD=1 is determined by the size of the constant 'c'. If 'c' would be high, approaching infinity, the universe would be small, approaching a dot. If 'c' instead would be low, there would be infinite distances between everything in the universe. If distances only exist on a macro scale, it would mean that "c" is a macro phenomenon. From a micro perspective the value of "c" would be infinitely large.

Time

With the alternative space-time model we can travel faster or slower in time than others, but our own time will always move forward in the same pace (there would be no possibilities to travel in time, i.e. in our own time). Other's time could however not only run in different speeds, on a micro level it could also run in different directions. Two particles could interact, where one of them is moving forward in time, and the other is moving backwards. Which one is moving forward and which one is moving backwards is totally arbitrary. From your point of view you will experience the forward moving particles as "particles" and the ones moving backwards in time as "anti-particles". The difference between particles and anti-particles is the charge, so we could define particles as having positive charges and antiparticles having negative charges. Charge would hence be something that is dependent on your frame of time.

"Time" on a micro level would however not be the same as the time that we are experiencing. In the same way as we could break down the space dimensions we can break down the time dimension. With the alternative space-time model only the order of events would exist on a micro level. The length of time between those events would only exist on a macro perspective.

<u>Quantum Mechanics</u>

The thought experiment with Schrödinger's cat is often used to illustrate the profound strangeness of Quantum Mechanics, with superposition of states and entanglement. If the cat is totally isolated in a box with a deadly poison that is released at a random time, the cat is supposed to be both dead and alive until a measurement is done. There is however a fundamental error in this analogy – from the cat's perspective, no time should elapse during the experiment if it should illustrate a quantum effect. The cat would argue that it was either dead at the moment it was put in the box, or that it is alive and never was in the box at all. Outside observers might disagree, however if they can prove that there is a cat in the box at any time during the experiment, the experiment will collapse.

So, what does this mean for the wave function and Schrödinger's equation? From the perspective of the cat it makes no sense at all. It is a model for describing everything that could and will happen in the box, and specifically what will happen to the cat. Since the cat won't even agree that it is ever (alive) in the box, this model seems useless. However, from an observer's position it makes more sense. It can accurately predict the state of the system, if the experiment is interrupted at any time. However, that the wave function is based on complex numbers (i.e. it includes imaginary parts) indicates that it should not be interpreted as an actual description of what is happening.

With the alternative space-time model there are no such things as "alive cats" if we use Schrödinger's analogy. A cat can be born and it can die, but it makes no sense to talk about something in between.

With the alternative space-time model it will be possible to interpret Quantum Mechanics from a local perspective. There will be a threshold in scale where the structure of space and time behaves differently. It is like zooming in on a digital photo – at some point you will loose the overall picture and only see the pixels. Some properties of space-time only exist on a global scale, such as distance and length of time. This could explain why it has turned out so difficult to combine general relativity (a theory based on a macro perspective) and the Standard Model (a theory based on the local perspective). The problem with Quantum Mechanics is that it describes the local effects, but transposed to a macro perspective. This causes paradoxes and difficulties in interpreting the theory.

To interpret Quantum Mechanics with the alternative space-time model, we have to view the universe as a web of connected particles. Assume that every particle in that web is connected to three other particles. The reason to assume three is that it is the smallest number that would be required to determine a particles position in three dimensions (and it would hence be a property of particles that determines that we are living in a world with three space dimensions). The connections could change continuously, but there are stable systems, such as for example the atom. A particle has a number of options to connect with other particles, each with a different probability. From the particle's perspective a connection is done instantly, however from a macro perspective this will be interpreted as if there is a fundamental uncertainty corresponding to the time it takes to establish the connection, as seen from an outside perspective. This should be the reason why the logic of Quantum Mechanics seems so difficult to intuitively understand.

In the section about "space" I raised the question how infinitely small particles could collide, without agreeing in advance, and why they don't collide in an atom. With the alternative space-time model particles will collide when they are connected to the same particles. That would be the definition of a collision. That would also explain why identical particles cannot exist in a stable system such as an atom. If they were identical they could connect to the same particles and thereby collide.

The Standard Model

The Standard Model consists of 38 particles and antiparticles. In addition, the model is determined by 19 unrelated parameters. Still, this is not enough to explain everything. Attempts to explain more results in growing complexity and many more required, but never observed, particles.

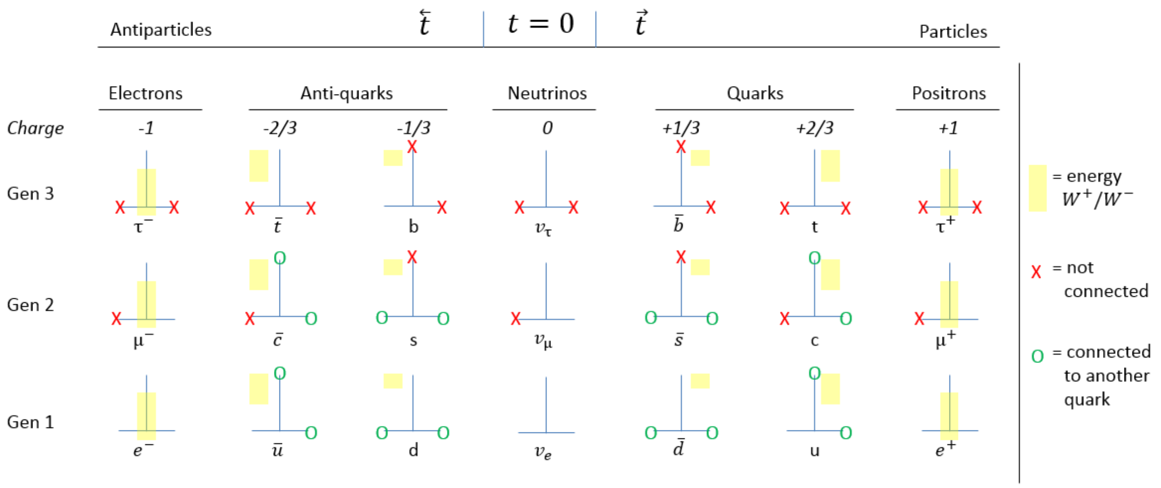
In addition to the complexity, there are two issues with the Standard model that are related to the initial hypothesis. First, the Standard Model is not background independent, meaning that it requires a space-time background. Second, it is based on a model of massless particles to transfer forces.

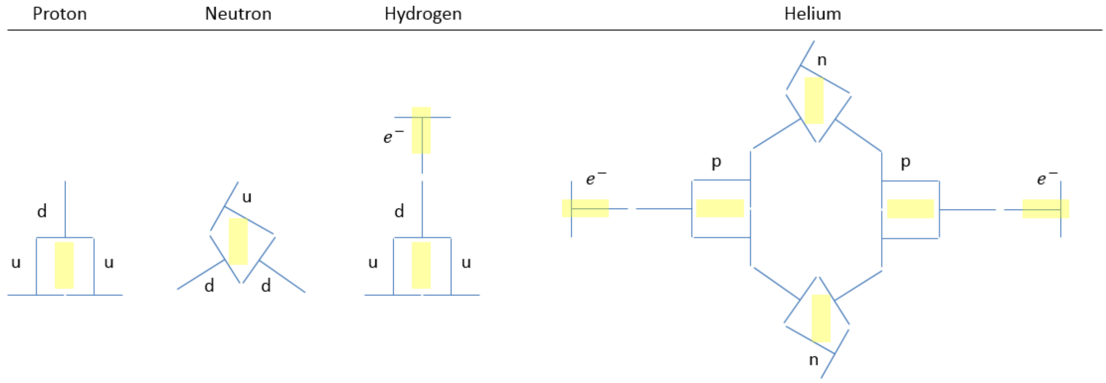
With the alternative space-time model, we have to rethink the Standard Model to some extent. To make the consequences tangible, let us assume that every particle have three connections to other particles. These connections enable exchanging attributes, i.e. energy levels. They could be one ways, enabling exchange over long distances (electromagnetism), or both ways for the other forces.

This model will give an explanation for why there are three generations of particles in the standard model. Different generations of particles would be the result of "open connections", where a particle instead of being connected to three other particles, only is connected to two or one. These states require high energy, and are unstable. It is not possible to create a composite space-time model like this one in three dimensions, without having different generations of particles (it would create problems with edges).

With the alternative space-time model it is questionable if neutrinos really are particles. They hardly interact with anything, so they have very small masses and thereby move with close to infinite speed (from their perspective). Time and space hardly exist for neutrinos. Should they be considered particles then? One way of interpreting them is to consider them the (empty) nodes, or potential, space-time. Add energy (in the form of a W boson) to a node and it will become a particle. I have assumed the neutrino to be a Majorana fermion, i.e. that it is it's own anti-particle. This would mean that the neutrino cannot interact using electromagnetism, and that the mass would be generated by interaction from the weak force.

With this point of view you will only need two things to explain everything in the universe – nodes of space and energy.





With this model, particles will act in a way similar to transistors. Empty space, i.e. a neutrino, is activated by a fixed amount of energy (corresponding to a W boson), thus becoming an electron. This enables the particle to exchange energy levels with other particles. However, unlike our ordinary transistors, a particle can also store (up to an infinite amount of) energy. It is also possible for three particles to share one W boson and act as one particle (three quarks creating a baryon).

A particle moving in the opposite direction of time is experienced as an anti-particle. There are hence exactly the same amount of particles and anti-particles in the universe, even if the mix between particles and antiparticles doesn't have to be fifty-fifty if you are only studying one direction of time. However, if we define all positively charged particles as "particles" and negatively charge particles as "anti-particles", hydrogen would consist of two particles (two up quarks) and two antiparticles (one down quark and one electron).

<u>Theory of Everything</u>

An objective of a Theory of Everything is to unite all forces – electromagnetism, strong force, weak force and gravity – in one model. Many have attempted, but it has proven difficult. With the alternative space-time model the reason is simple – gravity is not a force. Forces are different ways of exchanging energy – one way (electromagnetism), two ways (weak force) and three ways (strong force). Gravity on the other hand would be the macro effect of the physical structure of space-time on a micro level. In the scale of Quantum Mechanics, gravity doesn't exist. Quantum gravity models such as string theories and M-theory, or different approaches such as Loop Quantum Gravity, would all try to solve a non-existing problem.

<u>Cosmology</u>

From the view of cosmology today, the universe is an empty place. Even though there are hundreds of billions of stars in hundreds of billions of galaxies, the universe consists primarily of void. The alternative space-time model has a view which is much more dense. At a place where there is no matter there will be no space, since matter would be the precondition for space. Vacuum will not be completely empty, because particles can still occasionally be generated or interact within space of the vacuum. The energy associated with this vacuum activity should then correspond to the cosmological constant. Calculating vacuum energy using quantum field theory is a problem in modern physics. It results in a value that is more than 10 to the power of 100 larger than the cosmological constant, known as the “vacuum catastrophe”. This could be explained as the energy level if the vacuum wouldn’t have been empty.

A consequence of the alternative space-time model is that new space can be created. If a high-energy particle decays into several low energy particles, these particles will create new space. Space can in this way grow from within. There would hence be no need for unexplained dark energy to explain universe inflation.

Since every parts of the universe have their own time, it is not relevant to talk about an age of the universe. Neither does it make any sense to consider what we can see of distant stars and galaxies as something that happened along time ago. It makes more sense to say that it is happing now – the light reaches your eyes the same moment it leaves the star.

From a more philosophical perspective, a consequence of the alternative space-time model is that there is nothing outside the universe because space-time is bound to the particles in the universe. If something else than our universe exist, it would be in completely different space-times.

Black holes

With a model considering space as a web of interacting particles without any limit on how much energy they can store, there would be a possibility that a particle could be “over loaded”. At some critical level there would be so many particles interacting that it would be impossible for the particle to get rid of excess energy in the same time as new energy arrives. The particle would be caught in a self-reinforcing loop of increasing energy – which then would be a black hole.

A possibility would be to consider a black hole as a single elementary particle, with extremely high energy, that would continue to grow as long as there are other particles in the universe. When there are no other particles left in the universe the (generation I) particle would turn into a generation II and then III. When there are no particles left to interact with it would become a forth generation particle, i.e. a particle with three open connections – not connected to anything. Such a particle would be unstable, collapse and create particles and space-time in a new big bang.

This model would imply that the universe was created from one single elementary particle. Depending on if this was a particle or an anti-particle this could influence the development of the rest of the universe, favouring some particles and anti-particles over others. This could explain the current matter anti-matter balance without requiring CP violation in the early universe.