

Spacetime and matter as emergent phenomena

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Abstract

In this article, I propose radical super-deterministic non-gauge theory of emergent spacetime and matter, in which spacetime and matter are emergent properties of more fundamental entity. Properties of such more fundamental entity were analyzed, approach how to build emergent spacetime and matter with observable properties was proposed. It was shown how nondeterministic laws of quantum mechanics with gauge fields arise from super-determinism of underlying entity. The theory of emergent spacetime and matter (ESTM-theory later), as shown in the article, is compatible with Special Relativity, General Relativity, Quantum Mechanics with Standard Model and cosmology. Quantum Mechanics was reformulated in background-independent form. It was shown how Heisenberg's uncertainty principle arises in super-determinism of ESTM-theory. Changes in locality are proposed. Changes in equations of General Relativity are proposed in the article, same as changes to overall conceptual model of gravitation. Question is quantum gravitation exists is open mathematical question in ESTM-theory and it can be solved by more detailed analysis of equations of ESTM-theory. $SU(3)$ symmetry was derived in ESTM-theory and it was shown what Standard Model can be approximate solution of ESTM-theory. ESTM-theory unify all forces include gravitation; all forces are derived from one field.

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Introduction

Time is a phenomenon that each of us observe daily. But physics still not able to understand what is time. There is no evidence that time is independent phenomenon. Moreover, special and general theories of relativity established a dependency between time, space and gravitation. This suggests that time is not independent, and has relation with space and gravitation. We know properties of time. But there is no knowledge of why time flows, why time flows in one direction, are quants of time exists, why time is one-dimensional, is it possible to travel back in time.

There are some phenomena called as emergent. For example, second law of thermodynamic is one of emergent phenomenon. Properties of thermodynamic are based on underlying properties of individual atoms and molecules. However, equations of thermodynamic can be considered practically independent from equations of atoms and molecules. Currently, our spacetime and matter is considered as independent phenomenon. In the article I propose theory which considers our spacetime and matter, our being, as emergent phenomenon based on more fundamental entity.

This article presents theory of emergent space-time-matter (ESTM-theory later in the article). This theory considers space-time and matter as emergent properties of more fundamental entity. The fundamental entity includes everything objectively existing.

If look at physical phenomena around us, they are characterized by several key features:

1. They are caused by something. There are causal links leading to what is happening. Currently there are no phenomenon known that would not fall under causal links. Some phenomena, like radioactive decay, have probabilistic nature. However, while for radioactive decay we cannot say what was direct cause of decay and we cannot predict exact moment of time of decay, but still radioactive decay can be considered as caused by creation of unstable nucleus and it is possible to predict rate of decay.
2. We can predict probability of state of any object in future, with certain limitations, like not within gravitational singularity etc. In order to make such predictions, we need to know current state of the object, and current state of other objects in some distance around the object.
3. For some phenomena, we can predict behavior of objects in future only probabilistically. Quantum mechanics says that accurate prediction of state of quantum objects is not possible; we can predict only probability of states.
4. Laws of nature are same in all known space, in all non-accelerating reference frames.

How space-time can be built on system without time?

If there is no time as fundamental phenomenon, it means that underlying structure of Universe is completely timeless and it has no any changes. It cannot have any changes over time because it has no time. It is not even correct to say what underlying structure of Universe is static. Static implicitly means what something is not change over time, but it is not applicable for case when time is absent. Time in this case must be emergent phenomenon. Special theory of relativity establishes dependency between space, time and velocity. It means that if time is emergent phenomenon, observable space is also emergent phenomenon. General relativity establishes dependency between gravitation and spacetime. It means that in order to find emergent spacetime, it is necessary to find gravitation as another

emergent phenomenon. Quantum mechanics describes many quantum effects. It means it is necessary to find particles with quantum effects in scope of the theory. Standard Model shows what equations of all particles conforms to $SU(3) \times SU(2) \times U(1)$ symmetry. So, at least part of the symmetry must be derived. Another important feature of modern physics is uncertainly principle. So, it is necessary to show how uncertainly principle arises in the superdeterministic theory. Locality is another key stone of modern physics. So, the theory should include locality, may be in some modified way. All observable physical phenomena have causal relationships. As result, time should be built in such way so that phenomenon that occurred later on, would be possible to predict on basis of state before. Resulting laws of physics in emergent spacetime should not contradict to any well-established theory in its well-tested area of applicability. There are several fundamental forces in modern physics. Spacetime and matter should be built with usage of one only field, all other fields include gravitational field, should be derived from that one field.

ESTM theory, as I show later in the article, satisfies to all the conditions.

Let's imagine that space-time-matter, satisfying all conditions above, was found on basis of timeless system. Can such space-time-matter describe Universe, observable by us? If in such a world life is possible, can sentient being belonging to such world feel reality of surrounding and itself? These questions seem to refer to philosophy, as concept of Being is affected. However, different variants of answer to these questions provide different results in physics, so those questions are related to physics too. Postulate and main idea of this theory is positive answer to these questions.

Occam's Razor helps in positive answer to these questions, since this theory reduces number of independent phenomena and reduces significantly. Instead of various unrelated physical phenomena and independent space-time, this theory suggests that all physical phenomena can be derived from one model with one field and suggests ways to find it.

If in such space-time-matter, emerged from timeless underlying entity, there is sentient, it will observe following:

- Time exists, and all events have causal relationships, include relationships with probabilistic nature.
- There is past, present and future.

Why present time would exist? It may seem that in such system, time will pass immediately. However, it may be only from point of view of external observer. But external observer in this model cannot exist, first because of absence of time as fundamental phenomenon and second because underlying entity includes everything objectively existing. Observer here can be only object, capable of self-awareness, and belonging to emergent space-time. If such observer will be in emergent time, it will observe changes of states of surrounding. Human thought - it is some change in state of particles and fields in man over time. Consequently, observer, who lives in emergent time, will also be able to think, provided that relevant physics of emergent spacetime-matter allows for intelligent life to exist. The speed of its thoughts will be determined by rate of change of its states in emergent time. In particular point in space-time, observer will always have same thought. If this theory describes our Universe, it means that any human is, in some sense, immortal. Everyone exists forever, but when our present does not coincide with present of some other persons - they are not available to us. Similarly, at any point of present time our current present mind cannot contact ourselves in past or future. Also, number of human thoughts is limited by human lifespan. Anyone can do whatever he wants. However, desire of man to do something

is caused by state of human body at some point in time. Therefore, one cannot wish for anything other than what was set by his state, so there is no real freewill.

In modern physics, human's freewill is based on Heisenberg's uncertainly principle. In this article, I would show what the uncertainly principle is not contradicts to super-determinism of the theory; it arise quite naturally in super-determinism of the theory.

Postulate:

If in objectively existing timeless system, which includes everything objectively existing, it is possible to find space, time and matter as emergent phenomenon, and such space-time-matter allow existence of sentient, such space-time-matter is exists; it is emergent spacetime-matter. In such emergent spacetime-matter sentient can feel, think, feel that it really exists, is in being.

Consequence of this postulate: for case when laws of physics of emergent spacetime-matter allow intelligent life to exists, sentient belonging to such emergent spacetime-matter will feel like being in space and feel the passage of time. He will feel emergent physical laws; laws of physics of fundamental timeless system will be deeply hidden from his feelings.

Later in the article, I will discuss nature of time in more details.

It is possible to notice what postulate of the theory can be proven based on induction.

If, at some point of emergent time, human is able to think and feel reality of surrounding – he will be able to think and feel reality of surrounding at any other following moment of emergent time.

Proof:

ESTM-theory describe world with exactly same physical laws and phenomena as we observe. If it cannot describe some observable phenomena, it means ESTM-theory is not correct. So I assume here what ESTM-theory is able to describe world with exactly same physical laws and phenomena as we observe. So if human would not be able to think and feel reality of surrounding at any other following moment of emergent time – it means physical laws and phenomena of our world prohibit to humans think and feel reality of surrounding. It directly contradicts to observations, humans are able to think and feel reality of surrounding.

So, the statement is proven.

Similar for first step of induction, what human (or sentient) belonging to such world can think and feel reality of surrounding at some moment of emergent time. If it is possible to build exactly same laws of physics in ESTM-theory as in our world, it means what human will be able to be born, learn and start to think.

Postulate of ESTM-theory is more philosophical than physical, so the prove above can be questioned based on some philosophical views. So I have to use postulate instead of theorem.

After the postulate, I will add new definition, atemporal process:

Atemporal process: it is process which happens in absence of time as fundamental phenomenon and which include emergent time and happens over emergent time.

With such definition, all processes in our Universe are atemporal processes, assuming what underlying entity has no time as fundamental phenomenon.

I will name underlying fundamental timeless system as Metauniverse.

Metauniverse - objectively existing timeless system which includes everything objectively existing.

In the definition, I use phrase “objectively existing”. The phrase means what something exists, and it can exist with or without observer, independently from observers. However, the term indirectly implies possibility of existence of observer. But observer who can observe Metauniverse cannot exist, because there are no any models of intelligent life without time. “Existence” also indirectly implies what something happens in time, some object exists and time changing. There is no time in Metauniverse, so it means Metauniverse exists not in typical meaning of existence. So “objectively existing” is not precise phrase here, but it looks as closest available. The phrase here means what Metauniverse exists without any possibility of being directly observed by any observer and what word “existing” for Metauniverse is not imply any processes in time or time existence.

In Metauniverse I postulate existence of scalar field. This means that there is an m -dimensional space V , in which there is a scalar field $f(x)$, where x is point in the space of Metauniverse and the field is defined everywhere in space of Metauniverse. I also expect that space of Metauniverse is a Euclidian space. Minkowski space of General Relativity arises as emergent space, described later in the article. I expect that value of the scalar field at each point is determined by values of the field in neighboring points, and that equation of the scalar field is symmetric with respect to rotations, field is defined everywhere in space. This effectively means that position, speed and properties of all particles at each point of time are determined by states in past, present, future and in areas not belonging to spacetime, if they exist. In order to be able to predict distribution of states in future based on states in past, scalar field should have such properties. It means it should be possible to predict probability of states in some area of field with knowledge of states in another non-intersecting area of space of Metauniverse. Value of scalar field is defined by values in neighboring points because there are no carriers of field in timeless Metauniverse. What is particle and state of particle is described later.

Metauniverse has some number of dimensions. Number of dimensions in Metauniverse in this article is not considered. This is one of many questions in the theory that is left open for future. But Metauniverse should have at least 4 dimensions to include our Universe, reasons described later. One dimension for time, three dimensions for space. All four dimensions are space dimensions with same properties; there is no time in Metauniverse.

I will add definition of full universe:

Full universe is emergent spacetime-matter which has same laws of emergent physics at any point of emergent space and any emergent time.

Also, I will add definition of universe:

Universe is full universe at given moment of emergent time

Full universe includes spacetime and matter for entire time duration for the universe. Observer in such full universe can observe only state of universe at moments of emergent time. Because full universes are emergent spacetime and matter, all full universes are emergent universes.

Our Universe, in context of this theory, is one of emergent universes and at any given moment of time we can observe only state of Universe at some moment of time. This imposes some restrictions on possible topologies of Metauniverse. For emergent space-time-matter, therefore, it is necessary to find a way to find space, time and matter from these conditions.

Later, I will use word 'universe' mostly in meaning of full universe. For cases when I will use it in meaning of universe, it will be clear from context.

Methods of finding spacetime and matter will be described in several iterations.

Search for spacetime and matter

One of first questions which arise in timeless model of ESTM-theory is – how, in some point of space-time, move from one frame of reference to another frame of reference, moving with different velocity? In order to answer it, it is necessary to make model containing space and time.

Initial model for n-dimensional emergent spacetime-matter ($n \leq m$, where m is number of dimensions in Metauniverse) is:

- one dimension represents emergent time
- $n-1$ dimensions forms emergent space, with $n-1$ dimensions.

In such model point of space will move along line representing time. Emergent space is perpendicular to line of time, because it consists from other dimensions then time.

It is not possible to represent velocity by increasing or decreasing rate of movement along time line. Any emergent object moving along time line at any rate would have exactly same changes of its state as object moving with any other rate.

“Moving along time line” here is not means what object really moving. Model of ESTM-theory have no time, so there is no movement and no any processes in time, only atemporal processes. “Moving along time line” means consequent changes of state of object in consequent points on line of emergent time. I mention here “object”. Later I will use “particle” instead of “object”. Definition and properties of particles, how they arise from one field of Metauniverse, are written later in the article.

Movement from one frame of reference in some point of emergent spacetime to another frame of reference can be obtaining by rotation of spacetime in this point of spacetime. It means rotating both emergent space and emergent time. So, time line after rotation would not be same as before rotation, similar for space. Time line after rotation will have angle to time line before rotation. As result, distance between points on the time lines will grow proportionally to time line length. So, velocity in model of ESTM-theory was found, it is angle of rotation of spacetime.

State for any known to us object is depends on state of the object in past and state of objects and fields in some distance around the object in past, principle of locality; causality chains exists. In order to obtain similar properties from timeless Metauniverse, existence of mapping is necessary. I would not use isomorphism here, because isomorphism here means what previous state fully defines new state. Mapping here means what for each state of area of emergent space-matter at some point of emergent time can be set another set of states of area of emergent space-matter at some following point of emergent time and the set include all possible states for initial state. State of emergent spacetime-matter at some point of emergent time includes state of all particles at that point of time in area of emergent space. The set of following states should also contain probability of each set of states. So, the

mapping produces probabilistic physics from super-deterministic Metauniverse. The mapping should be between states of space-matter in present to states of space-matter in future. Time in this case is vector perpendicular to space. Transition to reference frame with another speed is obtained by rotating spacetime, as described above. First, I will require mapping function to be single valued (isomorphic), later I will discuss multivalued functions of mapping.

The approach with mapping can work well, but, based how ESTM-theory the mapping was added, it cannot be suitable everywhere. It is not represents underlying physics, it is just good approximate solution which allows predicting distribution of states in future for limited amount of conditions.

While such approach with mapping can works, may be even in some modified way, it is possible to talk about emergent spacetime. For areas where such approach is not works – they are not belongs to our spacetime. However, there are transitional areas and transitional energies.

Mapping function is not just another algebra and related groups and operators. However, mapping function should use map of states in past or present to create distribution of states in future. So, algebra of states is part of mapping function.

If states of some object cannot be described by same mapping function as for other objects belonging to spacetime, such object is not belongs to related spacetime, it is located outside of the spacetime and matter. Such object can belong to other emergent spacetime and matter, if it can be described by other mapping function, or it may not belongs to any emergent spacetime-matter. Object here means something constructed from scalar field of Metauniverse. In order for laws of physics to be same everywhere in spacetime, for inertial frames of references, mapping function must be same everywhere in spacetime. I not use “covariant” for laws of physics; the word is typically used in scientific articles. “Covariant” implicitly means that laws are changing covariant to metric tensor. But that if solutions for some universe with contravariant laws are possible? I cannot exclude it, so I use “same everywhere in spacetime, for inertial frames of references” phrase instead.

Maximum angle of rotation is limited by two factors:

1. By properties of scalar field of Metauniverse. Field may limit applicability of mapping function to only a certain range of rotations. Special Relativity limit maximum velocity to speed of light, it place limit of maximum angle of rotation.
2. Rotation cannot be made so that after one rotation time will points to past. But it not means that it is not possible to go to past after several rotations.

In our Universe, state of any object at time t depends on state of space and matter within vicinity of $c \cdot t$ around the object at time $t=0$. However, existence of such mapping is not enough, it is necessary to be able to switch to frame of reference of moving bodies. Matter is also necessary. I will introduce, in scope of ESTM theory, temporary definition of particle:

Particle – it is feature of scalar field of Metauniverse, which is stable at least for some emergent time and has invariant for rotations and interact in emergent spacetime with other particles as whole.

It means that some projection of scalar field of Metauniverse to emergent space, in vicinity of point x , with some modifications, not changing features of projection of the field and preserving invariant of particle, must exist along vector of time for some time. Mapping function should map projection of field to similar projection belonging to later time. Particle should interact with other particles as whole as long as it is one particle, because if only part of particle interacts and other parts are not interacts, it

means this parts are independent particles. Later in this article, the definition of particle will be expanded and modified; definition of elementary particle will be added. Movement of particle relative to point of emergent space – it is change in distance in emergent space from particle to point where line of time comes from initial position of the particle. In order to be able to go to reference frame of moving particle, it is necessary to have same mapping function in reference frame of moving particle. Because if mapping function is different, this means that in case of change of velocity of particle begin to act different physical laws. Transition to reference frame of moving particle is rotation of spacetime. Emergent time is always perpendicular to local emergent space.

Mentioned above properties of mapping imposes certain restrictions on equation of scalar field of Metauniverse.

Approach to formation of emergent spacetime-matter, described above, requires specific scalar field of Metauniverse. There is possibility to significantly reduce constraints to scalar field of Metauniverse. Instead of require from scalar field of Metauniverse ability of constructing continuous mapping function, it is possible to request to have this ability only in some points. In this case, space and time are discrete. Since spacetime of one reference frame is at angle relative to reference frame moving with another speed, this means that there is a minimum angle of rotation. Consequently, space of velocities also becomes discrete.

Above were described approaches that require single-valued mapping function. However, such function imposes lot of restrictions on original field. Of course, it leads to easier search for equation of scalar field of Metauniverse but I want to consider all possibilities. Mapping can be probabilistic; it means multi-valued function of mapping. This means that for same conditions of scalar field on surface representing emergent space, mapping may be one of a plurality of possible values, in accordance with probability distribution function. In this case, laws of physics in emergent spacetime-matter will also be probabilistic. Usage of probability function of mapping allows furthering weakening requirements for scalar field of Metauniverse. Probabilistic function of mapping does not mean that result of mapping cannot be predicted accurately. It can be accurately predicted with knowledge of function of scalar field of Metauniverse and boundary conditions. Boundary conditions, however, may be not belongs to emergent spacetime, part of them may belongs to future, part may be not belongs to emergent spacetime at all, some may be not reflected as states of particles. Probabilistic function of mapping generates probabilistic laws of physics in corresponding emergent spacetime-matter.

If mapping function is no single valued, it means that there is no isomorphism between states in past and future. Because same initial set of states can produce different set of states later. In quantum mechanics it explained by probabilistic laws of nature, in ESTM-theory I explains it as influence of factors external to spacetime and matter.

I will make several definitions with the approach:

World line - curve that starts at some point in spacetime, and includes all follows by time points.

World line is different for each frame of reference, i.e., through a single point in space passes so many world lines, how many rotations available. The curve is constructed by finding the closest following by time point belonging to same emergent spacetime-matter, then the nearest point to the found point, etc.

Distance between points in space belonging to same spacetime - is the number of points in the space located between them in the shortest curve for discrete solutions and length of this curve for the case of continuous solutions.

Distance in time between points belonging to same spacetime - is number of layers of space located between them for discrete solutions, and distance between spaces along world line of the selected point in case of continuous solutions.

With the approach described above, requirements for scalar field of Metauniverse further reduced. However, there is a problem with beginning of world lines. If world line is infinite and is not closed, Metauniverse must also be infinite. With endless world lines, our Universe must also be infinite. However, this contradicts current cosmological data about history of our Universe. So, I need to find way for emergence and completion of world lines.

World line is based on ability of mapping function to be same for entire emergent spacetime-matter. However, situation is possible when starting from a certain point of time mapping function cannot make proper mapping. It is possible that field of Metauniverse in such location have no anything unusual. If at some point of time mapping function cannot have correct mapping, in this point world line is terminated. Same is for beginning of world line. At some point, it becomes possible to use mapping function. At this point emerges spacetime and matter. However, emergence of one or more world lines does not mean appearance of new emergent spacetime-matter. For forming a space of velocities it is necessary to be able to perform rotations of spacetime, and number or angle of rotations must be equal everywhere. At beginning of world line it can be possible what full range of rotations with usage of mapping function is not possible. At that point it is not possible to say that time and space exist. This is transitional space, phase of forming space, time and matter. If by moving forward on the world line it is possible to reach emergent universe - hence the beginning of the world line was birthplace of new emergent spacetime-matter. If the world line breaks before reaching emergent universe - hence the formation of new universe was unsuccessful. What will happen if one of world lines that make up universe suddenly disappears? For example, there is a small place with some feature of field not allowing using mapping function. World line in many cases can be continued even when mapping function gives incorrect results if add into mapping function non-predictable component.

In the article, I would name as non-predictable every phenomenon which is not possible to describe based on probability.

Non-predictable component in this case does not mean absence of causal relationship; it just means that causal links are deeply hidden from the corresponding emergent spacetime-matter. At the moment, there are no experimental results which show existence of non-predictable phenomena in our Universe.

There is no phenomenon known with non-predictable behavior. Therefore most likely that non-predictable component is always zero or its influence is significant only at cosmological scale. Or it differs from zero only in the places of formation of spacetime. At the moment, only candidates for such places are vicinity of black holes with strong gravitational field and particles with Planck energies.

Above was given temporary definition of particles. Based on written above, modified definition:

Particle - feature of scalar field of Metauniverse or its decomposition, defined in area belonging to emergent spacetime, which is exists at least for some emergent time and has invariant under rotations

for some range of rotations as approximation, it interact in emergent spacetime with other particles as whole.

Additionally to already discussed, I added "*as approximation*". Why invariant, or symmetry to rotations, exists only as approximation I described later in the article, in Special Relativity part. In that would be shown what the approximation is not non-relativistic approximation, it's more complex.

It may looks as invariant should be precise, not approximation. According to Noether's theorem, continuous symmetries lead to conservations laws. If invariant for rotations is not precise it may leads to anisotropy of space and breaking of conservation law for momentum as result. Later, in Special Relativity part, it would be shown what the non-precise invariant breaks in such way it not cause anisotropy of space.

Adding non-predictable part to mapping function leads to necessary for emergent physical laws to be resistant to small changes in mapping function.

Space of velocities is formed by all possible rotations of spacetime at which there is no change of probabilistic part of mapping function and non-predictable part is much smaller than other parts of mapping function (deterministic part and probabilistic part). Rotation of spacetime corresponds to transition to reference frame moving at different speed. What means "non-predictable part is much smaller than other parts of mapping function" is described later in the article, in "Time, Space and Matter" part.

Speed of one reference frame relative to another - is function of number of rotations of spacetime for transition between reference frames. For continuous solutions - function of angle of rotation of spacetime, necessary for transition from one reference frame to another.

Accordingly, for discrete solutions of spacetime speed can vary only discretely. Observed velocity in corresponding emergent spacetime-matter is function of angle of rotation or number of rotations.

At any point in spacetime, there should be maximum angle at which it is possible to rotate the spacetime. Otherwise, using acceleration, it can be possible to go back in time.

Existence of maximum angle of rotation of spacetime means existence of maximum possible speed. In our Universe it corresponds to speed of light.

Based on written above, there are several possible options for emergent spacetime:

1. Continuous space, continuous time, continuous space of velocities
2. Continuous space, continuous time, discrete space of velocities
3. Continuous space, discrete time, continuous space of velocities
4. Continuous space, discrete time, discrete space of velocities
5. Discrete space, discrete time, continuous space of velocities
6. Discrete space, discrete time, discrete space of velocities
7. Discrete space, continuous time, continuous space of velocities
8. Discrete space, continuous time, discrete space of velocities

If SU(3) symmetry correctly describe particles, option #1 describes our Universe. The option implicitly means absence of quantum gravity, reasons described later in the article. If quantum gravity exists, in such case our spacetime is described by option 6. How SU(3) arise in ESTM-theory is described later in the article, but attentive reader may notice what SU(3) symmetry is already described just not named.

Noether's theorem is about differentiable symmetries, so it is applicable to option #1 only. As result, it makes other options questionable. However, it not discard them. May be universe without conservation laws are possible, or there is analog of Noether's theorem for discrete symmetries?

Interaction of past, present and future

According to ESTM-theory, we live in timeless Metauniverse, where time is emergent phenomenon. Field in Metauniverse is not changing because of absence of time, there is no preferred direction, and equations of field are invariant to rotations. It means every point belonging to past or present interacts with points in future. Also, it means future interacts with present and past. Because Metauniverse is timeless, it also leads to impossibility to go back in past, time machine, from point of view of observer not going to past, is not possible. It not prohibits time machine however: if there is some process which allows for some world lines to go to past, from point of view of observer moving with the world lines it may looks as they go to past. But from point of view of observer who not goes to past – nothing can go to past. Change of past is not possible, because Metauniverse is timeless.

Any states of objects in present are already have effect to past, and it is not possible to make states of objects to be incompatible with past.

Any attempt to make change of past would not has any effect. It is because those attempts are already affected past, even before we decided to do it.

Wave function

When I described above how to derive emergent spacetime and matter, I mentioned mapping function with probabilistic properties. As result, in ESTM theory all particles must be described by probabilistic laws of physics in emergent spacetime.

Quantum mechanics contains function which is used to describe particles, it is wave function. Wave function has probabilistic properties. In such case, if ESTM theory is valid, wave function must be function of mapping function, mentioned above. Exact relationship between mapping function and wave function can be found with further development of mathematical model of ESTM theory.

ESTM-theory and Standard Model, SU(3) symmetry

Particles in any state should be same after rotation of spacetime, as approximation. How Special Relativity affects rotations is described later in the article. In our emergent spacetime, there are 3 spatial dimensions. It means what particles should allow rotation in 3 orthogonal directions. Matrix for rotation in 3 orthogonal directions in 4-dimensional space is 3x3, if ignore time. Time can be ignored for non-relativistic case. Only one field exists in Metauniverse, and particles with their state are such dimensional parts of scalar field which are preserved by rotations. Note what same part of scalar field may represent more than one particle for same spacetime.

Probability of some particle to be in some state at some point of space in quantum mechanics is described by wave function. Wave function is function which uses complex numbers. Because ESTM-theory is expected to describe our Universe, I can use rotations for wave functions. Why particles have probabilistic properties, were described above. Wave function, in such approach, is function of mapping function described above.

So, wave function should also allow rotation of spacetime. It means what wave function should have symmetry to SU(3) group, as approximation and for smooth space without quants of space. Unitary because determinant of matrix for rotation is equal to 1, S because wave functions is based on complex

numbers. Smooth space – because if space is not smooth it means there are no continuous rotations and Lie groups are not applicable for such cases.

So, ESTM-theory predicts SU(3) symmetry, similar to Standard Model with SU(3)xSU(2)xU(1) . As for other parts of symmetry of Standard Model, it needs to be found in ESTM theory with further development of mathematical model.

There is no proposed equation of field of Metauniverse; search for the equation needs to be done with usage of reverse approach. It would be necessary to find such field which satisfies all constraints of ESTM-theory. SU(3)xSU(2)xU(1) symmetry is one of such constraints.

As result, I can conclude what Standard Model can be approximate solution of ESTM-theory.

With the model, it is possible to use same math as in quantum mechanics with Standard Model. Eigen vectors will represent states of particles; eigenvalues will represent masses of particles etc. Such approach is in line with definition of particle given above.

Standard Model describes strong, weak and electromagnetic forces. So, I can conclude what ESTM theory contains at least the three forces; how to add gravitational force will be described later in the article.

Algebras for emergent universes

During describing how to find particles on continuous scalar field of Metauniverse, it was shown what particles are properties of scalar field which has approximate invariants to rotations. What means approximate invariant, described later in Special Relativity part. Also particles should be same after rotation relatively to each other; it means what operators of rotations should be unitary. Wave function is based on complex numbers, so it should be SU(n) group with related algebra, where n is equal to number of space dimensions. In case of our Universe with its 3 space dimensions, it leads to SU(3) symmetry. It was shown below in Special Relativity part, SU(3) symmetry is only approximation because it cannot produce same physical laws after rotations.

So, each emergent space-time-matter with n dimensions is based on its algebra with group G . G is one of SU(n-1) groups with corresponding Lie algebra, which is unique for all intersecting full universes but can be non-unique for full universes which have no intersections. Reason why all intersecting full universes must have different algebras – because in case if two of them have same algebras, it means in place of intersections all particles belonging to first universe belongs to second and same for opposite. As result, it is same emergent spacetime, same universe.

Group G depends on function of scalar field of Metauniverse. Algorithm how to derive set of algebras based on function of scalar field is unknown. Also, the groups may be defined not in entire volume of Metauniverse, but only in some volume V of Metauniverse. Volume V corresponds to volume occupied by related full universe. More than one algebra can exists on same volume. So, group G is function of function of field $f(x)$ on volume V and it belongs to set of groups from the volume:

$$G(f(x), V) \in \{G_1, \dots, G_n\} \quad (1)$$

Note what group G is not need to be defined on all volume V , the volume can contains regions where the group is not defined or where there is breaking of the group. How to interpret the cases, is discussed in gravitation part of the article.

Uncertainly principle

One of main features of quantum mechanics is Dirac's uncertainly principle. It may looks as uncertainly principle is not compatible with super-determinism, include ESTM theory. In this part of article, I would show why uncertainly principle is not contradicts to ESTM theory.

ESTM theory is based on wave functions with proper symmetries. It means what all observables should be described by operators, similar to quantum mechanics.

Description how uncertainly principle is derived is described in most of textbooks for quantum mechanics. Main feature which leads to uncertainly principle is wave function and non-commutative operators for measurable values, such as location and impulse. I would not copy-paste deriving of uncertainly principle, it is enough to note what ESTM theory contains wave function, and so all maths of quantum mechanics can be used. As result, ESTM theory contains uncertainly principle too, in spite it is super-deterministic theory.

Uncertainly principle in ESTM theory is exhibition of non-corpuscular properties of particles.

Loss of information about past

Past - it's all events that have already occurred.

Can events, which already happened, be changed?

If non-predictable part of mapping function is non-zero, it is possible that we would see events different than they were at time when they happened. In this case, with distance from point of event will be accumulated non-predictable contribution. Chains of cause-and-effect relationships would be modified. In this case, it is possible that in same frame of reference, at points separated by a certain time, events in common past will look different.

It can be interpreted as loss of information about past.

I guess that non-predictable part can be non-zero only at space where at least some world lines are emerging and terminating. Such behavior of world lines can be expected to be found at curved spacetime, with strongest effects near gravitational singularities and black holes, may be somewhere else. Therefore, loss of information about past may be not observable under normal conditions.

It is necessary to solve equations of ESTM-theory to be able to describe such processes, and is they exist.

In order to estimate effects of non-predictable phenomena, if they are exist, I add additional definition: time of half decay of causality.

Time of half decay of causality – it is duration of time when half of causality chains, existed at beginning, would not exists at end of the time with given rate of non-predictability.

The definition is quite vague; because there is no exact definition of what is "causality chain" and how to calculate them. So the definition needs to be improved with future development of ESTM-theory.

Metauniverse and emergent universes

Metauniverse, according to ESTM-theory, is timeless space containing scalar field $f(x)$. All others – particles, time, space and others – are emergent phenomena.

Our Universe is part of Metauniverse. Volume occupied by a full universe in Metauniverse corresponds to sum of volumes of all spaces of universe since beginning of time until end of time, or until cycling of universe.

Methods for determination of spacetime, described above in the article, can provide several different solutions with different mapping functions. These solutions can cross in space of Metauniverse, or not overlap, or coincide exactly occupies same space of Metauniverse. It is also possible that in part of space of Metauniverse existence of spacetime is not possible and no universe exists in that place.

Each of these solutions corresponds, according to postulate of the theory, to objectively existing emergent universe.

I will introduce several definitions:

Multiverse – it is set of all universes, existing in Metauniverse.

Close universes – it is universes that have intersection in space of Metauniverse.

If universes are close to each other, it does not mean that particular region of spacetime of universe is close to region of another universe. Possibly, intersection happened billions of years ago, or it will happen in billions of years in future, or is happening in many mega parsecs away.

Locally parallel universes – it is all universes, which have intersection in space of Metauniverse with selected part of spacetime of universe.

If there are locally parallel universes, it not means that it is possible to interact between universes. For interaction between universes is necessary, but not sufficient, non-zero correlation between equations of particles belonging to the different universes.

Interacting parallel universes - universes, action in one of them may affect state in other universe, and vice versa.

If action from one universe to another universe will make rational being, in another universe such action will look as consequence of its own physical laws and it would have independent from first universe causality links.

Recently, in fantasy become popular genre with parallel Earths located in parallel dimensions. According to ESTM-theory, parallel Earths are possible, in case if accumulation of matter in one universe leads to accumulation of matter in some another universe. Simplest possible solution is for interacting parallel universes. Maybe extraterrestrial sentient are very close, on parallel Earth?

Properties of our spacetime

There are several possible options of existence of Universe:

1. Time in Universe has a beginning but no end.
2. Time in Universe has a beginning and there is end of time
3. Spacetime in Universe looped.
4. Time in Universe has no beginning and no end.
5. Time in Universe has no beginning but there is end of time.

All variants with infinite time assume infinite Metauniverse.

Modern experimental data show that time in our universe has beginning. It discards all options except 1 and 2.

Therefore, in beginning, until time appeared, was (and it still exists in Metauniverse, but far from us) some state where usage of same mapping function as now in our universe was impossible. Next, began formation phase of our Universe, which created space, time and matter. It is not possible to say how much time this process took, since time itself was also in phase of formation. Further development of the ESTM-theory, understanding physics of Metauniverse, should allow studying formation of our Universe in details and even looking further before Big Bang, to where there was neither time nor space.

End of formation phase is not means end of formation of new spacetime and matter. It is still possible and, at least for spacetime, happens, described later in the article in cosmology and gravitation parts.

Our Universe

In this part of article, I will describe how our Universe looks based on the ESTM-theory.

We are in timeless Metauniverse. Metauniverse has scalar field, space is a Euclidean space. Field is not uniform everywhere, somewhere it is more, somewhere less, but equation of field is same everywhere. Our Universe exists in Metauniverse, formed on basis of one of variants of formation of spacetime and methods for quantization, described above.

Mapping function, described above, must have no noticeable non-predictable parts on all available now for study range of energies and values of gravitational field. It should be possible to describe properties of particles and their interaction in above range of conditions based on their states. In this case, their accurate equations should have a range of states as solution for SU(3) approximation, so Standard Model would be approximate solution of ESTM-theory.

Gravitation warps emergent spacetime. Thus, gravitation does not affect character of interaction between particles on entire observed range of gravitational forces.

At same time, both quantum mechanics and general relativity, according to the ESTM-theory, are approximate and have restrictions on their range of applicability.

Both quantum mechanics and gravitation are emergent phenomena of scalar field of Metauniverse.

Special Relativity and ESTM-theory

Current experimental data shows what all laws of physics are same in all non-accelerating frames of references. So, in order to form time, all laws of physics should be same in all non-accelerating frames of references. Some physical laws like electrodynamics and Special Relativity, requires constant speed of light in all frames of references. It can be achieved by following model:

After each rotation, new maximum angle of rotation appears, from point of view of geometry of Metauniverse. It may be different then before rotations, but symmetric for rotation to any side. Speed of light must be not changed with change of maximum angle; speed of light depends not only on angle of rotation, but also on speed of time in Metauniverse (described more lately in the article). In such case, after making some amount of rotations in one direction, it should be possible to go to past, from point of view of accelerating object. From point of view of observer who not change its velocity, accelerating object would not go to past, it would just increase its speed to not more than speed of light or maximum angle of rotations, may be after some rotation it will be seen even as decreasing its speed. Particles of light must map to particles of light in other frame of references, same for particles. But

position of particles and their trajectory will change after rotation, and distance between trajectory of same particle but in different frames of reference may grow instantly over time. I want to highlight the result of ESTM-theory – same particle in each point always go to different trajectories depending on angle of view. How to find types of functions which allow such model is unclear for me, I think some models from holography can be used here. So, it requires more research to find mathematics of described model. In equations of ESTM-theory I will require such properties from related functions, but functions are not found. Again, ESTM-theory is new theory with completely new mathematical model. No mathematics exists in ready to use for the model state. I think it is possible to find such equations, but their search will take quite a lot of time. And ESTM-theory contains much more open questions; in the article I more focused on creation of basis of ESTM-theory than research in details each open question.

So, let's discuss the model in more details.

First, I will discuss possibility to go to past. If after each rotation (increase of speed) new maximum angle is allowed to go beyond previous maximum angle, it means possibility to rotate to 180 degrees from first rotation, go to past. However, because Metauniverse in ESTM-theory is timeless, it cannot be changed. So, attempt to change past with number of consequent accelerations should fail. However, from point of view of accelerating observer all should look as usual, same physical laws as before accelerating. So, if plan to make changes in past before accelerating, it should be possible to make them after accelerating. It looks as contradiction. The contradiction can be resolved, if add loss of information after rotating by big angle. Information should be fully lost if rotate to past, so original plans to change past would no longer be in effect. ESTM-theory leads to equations of ESTM-theory, and the equations are expected to describe any space-time-matter for any universe. Loss of information – it is cases when some events, like interaction of particles, happened in one frame of reference but not happened in another frame of reference. So, after rotation of reference frame some particles may disappear or appear, positions of particles in Metauniverse may be changed.

Photons and some other particles are always traveling at speed of light. So, they always have maximum possible angle to vector of time, other type of particles have less angle. The angle for photons is equal to angle representing speed of light. After rotation of frame of reference, surface in Metauniverse, corresponding to speed of light, will be different than before rotations. So in one frame of reference particles with speed of light belong to one surface, in another frame of reference, after rotations – to another surface, their positions in Metauniverse changing by rotations, some of particles may disappear after rotation, some appears. If rotate frame of reference, once or several times, and next rotate back to original position (if it is possible without exceeding speed of light), particles and their positions must be same as before rotations. Same applies to particles which not travel with speed of light. So there is loss of information after rotation of frame of reference, and there is change in direction of speed of particle after rotation of frame of reference. Note what described behavior means what $SU(3)$ symmetry is approximation.

Proposed above behavior is looks as not falsifiable, because it cannot be directly observed. Any theory which cannot be falsified cannot be considered as scientific theory. However, while ESTM-theory predicts there is no way to directly observe the behavior, there is ability to test other predictions and falsify ESTM-theory.

Such behavior, with inability to directly observe some phenomenon, is inherent part of any super-deterministic theory. The behavior cannot be directly observed, so it is not directly falsifiable, but it can

be tested and falsified by comparing other, observable, predictions of super-deterministic theory with experiments.

Same laws of physics in all reference frames look quite natural in ESTM theory. It is because the laws are emergent from mapping function. And for same initial conditions, mapping function should provide same results, because of symmetry of function of scalar field of Metauniverse.

Speed of light is same everywhere in non-accelerating frames of references. Speed of light, with approach described above, it equal to:

$$c = v_t * tg(\alpha) \quad (2)$$

v_t – speed of time in Metauniverse, α – angle between vector of time and light. Speed of time may change and, as result, the angle will change together with speed of time. Speed of light is speed in emergent space. Emergent space is perpendicular to vector of time. So hypotenuse of resulting triangle is located opposed to angle between speed of time and speed of light.

So, scalar field should have quite specific properties, described above, to support Special Relativity in ESTM-theory.

If angle of speed of light is much smaller than 2π , in such case loss of information may be small. It may be small with following condition:

$$\alpha \ll 2\pi \quad (3)$$

Described above behavior is not means what SU(3) symmetry must break for relativistic cases, but it means SU(3) is approximate model. Another conclusion is – quality of SU(3) symmetry depends on angle of speed of light. Later, in gravitation part, was shown what the angle is not constant. How it affects quality of SU(3) symmetry and laws of physics is discussed later in the article.

Special Relativity contains relation between time intervals in different frames of references. Such relation cannot be obtained in ESTM-theory directly from geometry. The relation imposes another restriction to scalar field of Metauniverse.

Now, I will write what was written above in equations.

Average value of 4-vector R of space and velocity for particle with wave function ψ is:

$$\langle R \rangle = \int \psi^* R \psi dr \quad (4)$$

From point of view of another frame of reference,

$$\langle R \rangle_1 = M \langle R \rangle = M \int \psi^* R \psi dr \quad (5)$$

$\langle R \rangle_1$ – 4-vector from point of view of another frame of reference, M – matrix for transformation. M is calculated based on Special Relativity.

Same 4-vector can be calculated as:

$$\langle R \rangle_1 = \int \psi_1^* R_1 \psi_1 dr_1 \quad (6)$$

ψ_1 – wave function from corresponding frame of reference.

Behavior with position of particles after rotation to another frame of reference means what there is difference between position predicted by Special Relativity and actual position in related frame of reference, so what module of difference between 4-vectors is above zero:

$$|M \int \psi^* R \psi dr - \int \psi_1^* R_1 \psi_1 dr_1| > 0 \quad (7)$$

if frames of references are not same. I will name the difference as function θ :

$$\theta(v, \beta, G, L, \vec{v}_t) = |M \int \psi^* R \psi dr - \int \psi_1^* R_1 \psi_1 dr_1| \quad (8)$$

$$\theta(v, \beta, G, L, \vec{v}_t) > 0 \text{ if } v > 0 \quad (9)$$

The function depends on velocity v of another frame of reference; angle β corresponds to the velocity in point of emergent spacetime. Note what the angle can be different in different points. G – group with related algebra of particles, for our Universe it corresponds to algebra of Standard Model. L is function of emergent space, \vec{v}_t describes emergent time, both function are described later in the article, in gravitation part. The function can depend on other parameters. If other parameters exist, they can be found with further development of mathematical model of ESTM theory. And again, I remind what the difference cannot be experimentally measured, it is prohibited by super-determinism of the theory. So, while the symmetry is only approximation, from point of view of observer in emergent spacetime, the symmetry is close to precise. As result, Noether's theorem is still applicable for SU(3) group and conservations laws are exists.

Time, Space and Matter

There are many definitions of time. Most of them says what time is phenomenon completely independent from observers, and it exists both when observers exists and not exists.

In ESTM-theory, we exists in timeless Metauniverse, there is no time as phenomenon on level of Metauniverse. Time appears as emergent phenomenon. But is such time exists without observers? Without observer, it cannot be measured. Without observers, emergent time is just mathematical abstraction. So time and any effects of time without observer cannot be experimentally tested, and, as result, it becomes question of philosophy. My opinion is: without observer time is not exists unless observer appeared at some more late emergent time. Only intelligent life can be observer. So, time exists only if related emergent universe contains intelligent life.

Similar is for space. Space, as emergent phenomenon, exists only if observers exist in related emergent universe.

Matter is also emergent phenomenon, and it not exists without observers.

Intelligent life cannot exists without causality, when events in past affecting events in present. At least, as far as I know, nobody proposed models of intelligent life in physics without causality.

As result, from one point of view time is automorphism of algebra of universe. From another point of view it is possible to say what time is subjective ordering of set of emergent space-matter which support causality chains

Subjective is because time is not exists without observer. Each moment of time contains different space and matter. Each state of space-matter at following moment of time should be, at least partially, be based on state in previous moment of time, in order to support causality chains. State of space-matter at following moment of time can be not fully based on state at previous moment of time, as long as it

allows existing for some causality chains. Causality chains should exist for long enough time to allow arising of intelligent life, otherwise related universe would not have intelligent life as it means such universe has no observer. Without an observer at some point of emergent space-time, the universe does not exist.

So, if laws of physics contain non-determinism, it should be small enough to allow existence of intelligent life.

The definition of time is in line with the proposed model of finding emergent space-time-matter and described above properties of emergent time.

In this part of the article it is easy to notice what ESTM-theory is based on a non-realistic philosophy view with eternalism, because one of its consequences is that spacetime and matter do not exist independently of our mind. However, I think that the theory is more closer to critical realism than anti-realism, because it contains entities independent from mind. It is field and space of Metauniverse. More precisely, mind is dependent on the scalar field but the field is not dependent on mind.

Holographic principle of ESTM-theory

Metauniverse in ESTM-theory has no time, so it does not contain any particles, except in emergent universes. As a result, there are no force carriers for the field, so each value of the field in a point of space of Metauniverse should be defined by values of the field in neighboring points. I will name it as the holographic principle of ESTM-theory.

Holographic principle of ESTM-theory is incompatible with the Holographic Principle of String Theory. Reason is not only because ESTM-theory has no strings, but also because the boundary of a region in ESTM-theory includes not only the past, but the future too. Also, particles in ESTM-theory are just some emergent objects based on the field of Metauniverse, and knowledge of the state of particles is not sufficient to fully describe the state of the field inside the region. States of particles are just eigenvectors in some Lie group and related algebra ($SU(3) \times SU(2) \times U(1)$ group of Standard Model for our Universe), and the set of states of particles is not providing full information about the state of the underlying scalar field of Metauniverse in the related region.

The field in Metauniverse does not change over time because there is no time, so no any carriers of interactions are possible. It limits interaction to only one case – when the field in some point interacts only with points near.

So, it leads to: if there is some closed surface S in Metauniverse, the value of the field inside any point of the region surrounded by the surface is determined only by values of the field on the surface, $\varphi(S)$.

So, it means there exists a function $g(\vec{r}, S, \varphi(S))$ which gives the value of the scalar field of Metauniverse in point x belonging to the region surrounded by surface S , where the value of the field on the surface is $\varphi(S)$:

$$f(x) = g(x, S, \varphi(S)) \quad (10)$$

Holographic principle of ESTM-theory may lead to an interesting conclusion: full information about the entire Metauniverse and all its universes exists in any region of Metauniverse. Such conclusion may be valid in the case of a smooth function of the field of Metauniverse; probably some other restrictions are required.

Locality in ESTM-theory

All known interactions in our Universe are local, with speed of light as limit to speed of interactions. There is also quantum entanglement which seems as having faster speed of information movement than speed of light.

Locality in ESTM-theory is achieved with SU(3) symmetry. All particles must conform SU(3) symmetry, and none of particles may have speed above speed of light. All particles interact between each other only with usage of other particles or directly without violation of locality. Maximum speed for all particles is speed of light. As result, there is locality.

However, ESTM-theory not prohibits faster than light interactions if they involve particles with macroscopic size. In case of particles with big size, particle interacts as whole and, as result, it corresponds to interaction with faster than light speed.

Gravitation interaction may not have field carriers at all; it can be just mathematical function which provides ordered set of emergent spaces which support specific kinds of particles and causality. But because there are no any observations what gravitation interact at speed above speed of light, such function also must support locality. Curvature of spacetime in such case is caused by function of gravitation to support causality and locality.

About possibility of direct interaction between particles without violation of locality.

There is open question. Is it possible to build universe based on particles with violation of locality and make the universe be able to support causality chains and intelligent life?

Gravitation, part one

During description how to find spacetime from scalar field, I mentioned what emergent laws of physics must be same for all spacetime and for all frames of references. It is possible what in some cases emergent spacetime will be curved, because there are no solution with non-curved spacetime in some areas of Metauniverse. As result, we would observe curved spacetime.

Curved spacetime is not something new, General Relativity use curved spacetime to describe gravitation. So, I would assume what curved spacetime is responsible for gravitation, similar to General Relativity.

Why gravitational mass is equal to inertial mass is open question, it is necessary to find way how to calculate both of the masses to be able to find answer.

Due to fact that particles change spacetime, is that if will be big enough number of particles - there can be problems with spacetime and world lines. At some point, continuing of spacetime can be impossible. At that point, there is gravitational singularity. Close vicinity of gravitational singularity is place for massive formation of spacetime and for formation of matter. There may emerge and terminate world lines, and particles.

Gravitational singularity does not mean that at point of singularity Metauniverse also has singularity of scalar field. It does not even mean that in these places value of scalar field of Metauniverse is higher or lower than average, it just means there is no solution which supports same causality and emergent laws of physics as in other parts of emergent spacetime.

During search for spacetime, one of condition of spacetime was – all laws of physics should be same in all emergent space, for inertial frames of reference. It allows using equivalence principle from General Relativity which says same. So, I can use General Relativity for ESTM-theory. However, some changes are necessary to made to General Relativity.

General Relativity predicts time dilation – time in areas in stronger gravitational field tick slower than in areas with smaller gravitational field. In order to get same for emergent spacetime, it is necessary for speed of time be higher in areas with stronger gravitation fields than in areas with smaller gravitational field. In such case events in stronger gravitational field would looks slower from point of view of observer in smaller gravitational field.

Speed of time – it is length in Metauniverse corresponding to unit of time in some point of emergent spacetime.

It is possible to write equation to set dependency between speeds of times depending on time dilation. Observer in smaller gravitational field during time dt_1 passes same distance as observer in stronger gravitational field during time dt_2 which corresponds to time dt_1 . So, speed of time v_1 for first observer should be different from speed of time v_2 for second observer.

$$l = v_1 dt_1 = v_2 dt_2 \quad (11)$$

As result:

$$v_1 = v_2 \frac{dt_2}{dt_1} \quad (12)$$

Speeds of time are different proportional to relative time dilation.

Such approach partially changes intrinsic character of spacetime curvature of General Relativity to combination of extrinsic and intrinsic curvature of spacetime. Also, it allows using absolute value of speed of time to compare time dilation with any other point, include other universes. Without such interpretation of time and speed of time, time dilation is something one reference frame has relative to the other in same universe and using it as absolute value does not make sense, there is no time dilation for comoving observers at different time of Universe. With adding absolute value of speed of time, appears time dilation between comoving observers belonging to different time of Universe.

Note what adding speed of time can explain inflation phase of early Universe. If speed of time at early Universe was much higher than now, emergent space can grow very fast, if Universe comes from small initial volume with high gravitation.

In ETSM theory, both space and time are emergent atemporal processes in Metauniverse. As result, additional to intrinsic space curvature of Metauniverse, can exists extrinsic curvature, caused by curvature of emergent spacetime in space of Metauniverse. Such extrinsic curvature can be zero only if emergent spacetime of our Universe is flat, on cosmological distances, in space of Metauniverse. However, modern cosmology data shows what our Universe had origin. It means some time ago Universe was much smaller than now. It means Universe is expanding in space of Metauniverse. So, Universe should have external curvature, the curvature should be above zero because Universe is expanding, and the curvature may change over time. So, the external curvature may be function of something. As result, external curvature Δ_{ext} needs to be added to equations of General Relativity as addition to cosmological constant Δ :

$$G_{\mu\nu} + (\Delta + \Delta_{ext})g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu} \quad (13)$$

This change is not contradicts to experimental data, if for all observable history of Universe:

$$\Delta \gg \Delta_{ext} \quad (14)$$

Δ_{ext} is not constant, but it is function which depends on unknown parameters. I think what one of such parameters can be age of Universe. Without more detailed mathematical model of ESTM theory, it is not possible to predict function of external curvature. However, it is possible to make some guesses.

One of possible guesses – our Universe is surface on 4-dimensional hypersphere. It allows having Universe with origin from small volume and expanding.

Note what curved emergent space means asymmetry between directions of time. Because if SU(n) group works in one direction of time, it not means it works in opposite direction with curved space.

Cosmological constant

Cosmology constant is usually interpreted as dark energy which is responsible for accelerated expansion of Universe.

All current cosmology models predicts that Universe had origin, and was interactions between all areas in past. Low difference in cosmic microwave background shows that Universe had nearby no differences initially.

It seems as most simple way to explain cosmology constant in ESTM theory is interpret it as properties of space and field of Metauniverse. In such case, it is possible to make several guesses.

One of them: emergent spaces should have same value of cosmological constant if they have same distance in space of Metauniverse:

$$\Delta_1 * L_1 = \Delta_2 * L_2 \text{ if } L_1 = L_2 \quad (15)$$

Another possible guess: emergent spaces should have same value of cosmological constant if they have same distance in space of Metauniverse multiplied by speed of time:

$$\Delta_1 * L_1 * v_{t1} = \Delta_2 * L_2 * v_{t2} \quad (16)$$

Such guess is to take into account what for bigger speed of times, same emergent force from space of Metauniverse can affect gravity more than for cases with smaller speed of time.

Quantum gravity and ESTM-theory

During search for spacetime, I required mapping function to be same everywhere in emergent spacetime. It can be written in another way: all laws of physics must be same everywhere in emergent spacetime. Gravitational force plays big role in building emergent spacetime. Our spacetime may be smooth only if gravitational force is also smooth. If gravitation force has quants, both emergent time and space should consists of quants of spacetime. Reason – if gravity has quantum effects, it affects at some point of spacetime, and not does any effects for some other time. And it has quant of spacetime as result. Similar for space of velocities – if there are quants of gravitation, space of velocities must be

discrete. As of now, there is no any evidence what either time or space has quants. Equations of quantum mechanics are valid only if time is smooth, non-quantified, parameter.

If there are quants of time or space, SU(3) symmetry will be approximate even for non-relativistic case, because Lie algebra assume continuous range of transformations. Also, all particles of Standard Model, based on SU(3) symmetry, are already discovered.

Possible argument how quantum gravity can exists in model of ESTM-theory: quants of spacetime are exists, but they are exists as some correlations in SU(3) model. In such case, they are described not by eigenvectors, but some more complex function like correlation of eigenvectors or may be even completely different. I see possible counter-argument in ESTM-theory. Laws of physics should be same everywhere in spacetime. Is it possible to achieve them if spacetime consists of quants of spacetime? So, further study of mathematical model of ESTM-theory and proposed equations would allow understanding is quantum gravity exists in our Universe if ESTM-theory is valid.

Gravitation, part two

Above, were described proposed changes in equations of General Relativity. But is it possible to derive equations for gravitation directly from model of ESTM theory? In this part, I will try to do it. However, resulting equations requires lot of improvements to become usable in calculations.

Emergent space can be defined by equation, where for each point x of Metauniverse, for group G of particles and for time, it should returns zero if point x belongs to emergent space for specific moment of time:

$$L(x, f, S, \varphi(S), G, \vec{v}_t) = 0 \quad (17)$$

\vec{v}_t – it is vector of time in Metauniverse. The vector is necessary, because in some point can be lots of emergent spaces with different vectors of times. L is function which returns zero if point x belongs to emergent space for specific moment of time, it is not lagrangian. It is not too complex to use equations of General Relativity with changes from ESTM-theory to write this equation in approximation without quantum effects.

Using same approach as in equation above for writing function of emergent time:

$$\vec{v}_t(x, f, G, L) = 0 \quad (18)$$

L – emergent space, \vec{v}_t – speed of time, vector.

So, resulting equations of gravitation:

$$\begin{cases} L(x, f, S, \varphi(S), G, \vec{v}_t) = 0 \\ \vec{v}_t(x, f, G, L) = 0 \end{cases} \quad (19)$$

The equation should result in emergent spacetime described by Eq 13, and should produce Minkowski space of General Relativity. Both functions in Eq 19 are unknown. In order to be able to use the equations for calculations, it is necessary to find how to derive the functions directly from equation of scalar field of Metauniverse and related group G of particles.

The equations of emergent space and time may have breaking of continuous solution, it may contains areas where spacetime is not defined. It means what either there is no same spacetime and matter in

the areas, or there is no connection between spacetimes with same laws of physics between the areas. For our Universe, such objects are black holes.

Physics of early Universe

In one of previous parts was shown what quality of SU(3) symmetry, same as quality of particle based approach, depends on angle of speed of light. In gravitation part, it was shown that the angle can become smaller in strong gravitational field.

Direct result of it – it is possible to conclude what quality of SU(3) symmetry for particles was better in early Universe, in case if early Universe had strong gravitational field. Same can be applied for SU(3) symmetry in strong gravitation fields. Can it result in differences in SU(2) or U(1) part? I will leave the question open, more research of math of ESTM-theory is necessary to answer the question.

Nature of scalar field

One of question which was not discussed above is: what is scalar field of Metauniverse?

It is possible to make some guesses; I not have definite answer now.

One possibility: what is the field is unknown, we just assume it exists and use equations to find its properties and resulting emergent universe with our laws of physics. If solving of equations of ESTM-theory with this approach will result in success, it would means the question will be left open for future.

Emergent spacetime and matter, equations of ESTM-theory

In previous parts of the article, I described idea of ESTM-theory, next checked is ESTM-theory compatible with known physics. I proposed changes to some theories, to make them compatible with ESTM-theory. Some equations were proposed for some parts of ESTM-theory. All of above created ground to build mathematical model of ESTM-theory. Predictive power comes to physical theory only with mathematical model, without mathematical model theory can give only very rough conceptual vision. In this part of article, I will write equations for ESTM-theory.

So, exists scalar field $f(x)$, where $x = \{x_1, \dots, x_n\}$ is point in n-dimensional Euclidean space. Value of field in any point is determined by values in all other points of Metauniverse.

Our current knowledge about physics of Universe says what three forces in Universe have particles, carriers of interaction. Electromagnetic force has photons as carriers of interaction etc. One exception is gravitational force, particle-carrier of the interaction is not found as of now. Field in Metauniverse is static because there is no time, so no any carriers of interactions are possible. It limits interaction to only one case – when field in some point is interacts only with points near.

So, it leads to: if there is some closed surface S in Metauniverse, value of field inside any point of region surrounded by the surface is determined only by values of field on surface, $\varphi(S)$. In this region it is necessary to find emergent spacetime with matter. It leads to equation 10.

Next, as was written above, it is necessary to have some near-invariants for rotations to have particles. It leads to necessary to have groups for particles, Eq (1). It can be possible to find more than one group in some region of space of Metauniverse. In such case the groups produce different emergent universes and particles from different universes are not interact between each other, except may be some correlations may exists between them. States of particles is set of eigenvectors from related algebra, mass is eigenvalue.

Particles must interact in space and time. So, it is necessary to find emergent space and time. Equation 19 places some restrictions on emergent space and time.

Emergent space can be defined by equation, where for each point x of Metauniverse, for set of

Next, it is necessary to add support of Special Relativity.

Equation 2 says what in ESTM theory speed of light is always constant. Equations 8 and 9 explains how to make speed of light without contradictions in resulting equations.

All particles in our Universe travel at speed not higher than speed of light. So, angle between vector of time and trajectory β of particle should not exceed such angle α_l for light.

$$\beta \leq \alpha_l \quad (20)$$

Combining equations together, system of equations of ESTM-theory:

$$\left\{ \begin{array}{l} L(x, f, S, \varphi(S), G, \vec{v}_t) = 0 \\ \vec{v}_t(x, f, G, L) = 0 \\ c = v_t * tg(\alpha) \\ \beta \leq \alpha_l \\ \theta(v, \beta, G, L, \vec{v}_t) = |M \int \psi^* R \psi dr - \int \psi_1^* R_1 \psi_1 dr_1| \\ \theta(v, \beta, G, L, \vec{v}_t) > 0 \text{ if } v > 0 \\ f(x) = g(x, S, \varphi(S)) \\ G(f(x), V) \in \{G_1, \dots, G_n\} \end{array} \right. \quad (21)$$

Interaction of particles with such approach can be found by following approach, if all functions, include scalar field, is known:

1. In some frame of reference find all particles everywhere in emergent spacetime
2. Interaction of particles is found: just look at how particles behave from point of view of emergent spacetime.

If look at equations above, there is no any isomorphism between emergent spaces belonging to different times, not even speaking about diffeomorphism. So, lots of math typically used by physics is not applicable to the equations, seems as only functional analysis applicable to them.

The system of functional equations above is very generic. In order to make them usable, it is necessary to find function of scalar field $f(x)$. If function of scalar field, Eq(10), was known, in such case laws of physics in our Universe can be found by finding of detailed equation for gravitation, Eq 19 and by adding non-gauge part to Standard Model. We observe only emergent spacetime and matter, so problem for solving is much more complex than find emergent universe from known function of scalar field. First it is necessary to find equation of scalar field from our observable laws of physics, and only next find equations of particles, space and time from scalar field, expecting increase of our knowledge of emergent laws of physics as result.

How it can be done?

I think first it is necessary to solve problem of finding algebra of particles and emergent spacetime with causality for general case. Solution of the problem will limit possible types of equations of scalar field and types of Eq(10), and it can give hints how to solve opposite problem of finding equation of scalar field from emergent spacetime.

After finding possible types of equations for Eq(10) it would be necessary to find which types would allow to have hyperbolic partial differential equations as solutions on emergent space for particles, at least as approximate solution for small angles of rotations. Maxwell equations and many other equations are hyperbolic partial differential equations; such types of equations are wave-like and can have constant speed of light. So, it can limit possible types of equations even more.

After identifying possible type of equation, it would be necessary to find how to build equations for scalar field to get Standard Model as approximate solution at least for small non-relativistic velocities. Small velocities because at higher velocities may become significant effect of loss of information during rotations. General Relativity should arise too, as solution for emergent spacetime.

Looks as solving of equations of ESTM-theory is complex problem and it will require quite a lot of research. I leave the question open for future.

Arguments against ESTM-theory

Scientific arguments against ESTM-theory

In this part, I will try to summarize expected arguments against ESTM-theory and answer to them.

I expect several main types of arguments:

1. Universe cannot have timeless underlying structure. Just look around, there is motion, there is time. This theory directly contradicts to our feelings.
2. ESTM-theory predicts following behavior for some phenomenon. Experimental results differ from predictions of ESTM-theory.
3. Is function of scalar field, satisfying all requirements of ESTM-theory, can exists?
4. ESTM theory shows what particles must have $SU(3)$ symmetry, but Standard Model have $SU(3)\times SU(2)\times U(1)$ symmetry.

I will try to answer to these arguments here.

First, I will answer to argument #1, about contradiction of ESTM-theory to our feelings. I think the argument is not scientific; it is just expression of philosophical bias. Any scientific hypothesis should be considered based on its predictions, not based on how well it fits to common sense. Nature has no any obligations to respect common sense of humans.

About argument #2. It can be serious argument, but at current state of ESTM-theory, ESTM-theory cannot make any measurable predictions. So, in order to make real arguments here, it is necessary to solve equations of ESTM-theory first or at least find some predictions based on the equations.

About #3. I cannot say for sure what such function can exists, some research is necessary to answer the question. However, I can say what it is not possible to say what such function cannot exists without additional research. Research related to analysis of existence of such function is outside of scope of the article; probably it will be in one of following articles.

About #4. Yes, it is problem. However, future development of the theory may resolve the problem. The $SU(3)$ symmetry of ESTM theory is not contradicts to $SU(3)\times SU(2)\times U(1)$ symmetry of Standard Model until it would be shown it is not possible to build $SU(3)\times SU(2)\times U(1)$ symmetry in ESTM theory. Mathematical model of ESTM theory is improving over time, so in future answer to the problem may be found.

ESTM theory has no local hidden variables. While $SU(3)$ is considered as approximation in ESTM theory, it done in such way what it not leads to observable violations of $SU(3)$ symmetry. It means what Noether's theorem is still applicable to the theory, and the theory has conservation laws.

Of course, I cannot predict all types of scientific arguments against ESTM-theory, so I tried to answer only most expectable types of arguments.

Non-scientific arguments against ESTM-theory

Just recently I received such feedback on ESTM-theory: "This work is simply not physically sound."

After some thinking, I understood it can be quite common perception of the theory. So I decided to answer to such argument.

I consider such argument as non-scientific. Such argument simply means what any person, who says it, sure what his philosophical view of Nature is true and sure what ESTM-theory cannot be true because it contradicts to his philosophical view of Nature. May I see where it was proved? I have read many debates about realism vs anti-realism in Internet, and I have not seen any mentioning what realism was proved to be true.

It is very unusual when scientific theory directly use ontological view to derive its model. ESTM-theory is based on eternalism. If look at postulate of ESTM-theory and look how spacetime and matter was derived, it is easy to notice what ESTM-theory was derived directly from eternalism with only few additional assumptions. However, there is nothing in ontology which prohibits deriving of physical theories directly from ontological ideas.

May be ESTM-theory requires too much changes in philosophical view of Nature and there is alternative which is not requires so many changes? Well, may I read any hypothesis which is not requires so many changes and which unify all forces? There are theories like String Theory, Loop Quantum Gravity etc., and some thinks they can unify all forces. But where is result with unification? It is not exists, as of now. ESTM-theory, on other side, proposes simple unification. The unification is easy to explain and understand, but only if one is ready to seriously consider the theory instead of insisting on his philosophical views.

I understand it is possible what ESTM-theory is wrong. But only scientific arguments should be used in science to prove what something is wrong, philosophical views should not be reason for rejections of new scientific ideas.

Applying ESTM-theory to some known problems

Information and black holes

There is loss of information in black hole in modern widely accepted theories.

There is no any loss of information in ESTM-theory. Information may leave our spacetime, but it still exists in Metauniverse, just it is not available for us.

Singularity in black holes, predicted by General Relativity, in ESTM theory is breaking of emergent spacetime. Beyond some space, approach with emergent spacetime is not works to describe resulting physics, and full equations of ESTM theory are necessary to describe whats happen inside.

Conclusions

The proposed ESTM-theory has two parts: philosophy and physics. So, I think it is better to split conclusion part into two sections: philosophy part and physics part.

Conclusions, philosophy part

ESTM-theory gives new interpretation of Being and removes real freewill from human. The theory is super-deterministic theory, so it gives no real freewill to humans. The theory proposes answer to one of big philosophical questions, how emergent spacetime-matter and our feelings relates between each other.

Being in ESTM-theory is emergent phenomenon, it happens over timeless Metauniverse.

Is model of ESTM-theory fits into long term philosophical trend?

Some time ago widely accepted theory was Ptolemy theory, where Earth was in center of Universe and Sun orbited around Earth. Human was in center of Universe, animals were apart from humans.

Later, erosion of centered role of human in Universe begins. Earth begins to rotate around Sun, and Sun become center of Universe. Next it was found Sun is just one out of billions of other stars, and Sun rotates around center of Galaxy. Darwin has shown humans have same origin as other animals.

Currently, role of human in Universe is still high. It is high mostly because of freewill conception – that human is free to do everything.

So, in science and philosophy there is long term trend to reduce role of human in Universe. ESTM-theory removes human's freewill and reduce role of human in Universe, and it fits to long term trend in science and philosophy.

Philosophy of ESTM-theory may looks as far from beautiful, because it so diminishing role of human. It reduces conscience of human just to epiphenomenon. However, Nature has no any obligations to respect human's feelings.

Conclusions, physics part

ESTM-theory is built upon one scalar field, so it unifies all elementary forces.

I see main power and main achievement of the theory in simple conceptual model unifying Standard Model and General Relativity, resulting in set of equations for ESTM-theory. The equations, if ESTM-theory is valid, should be able to describe all physical processes include undiscovered yet. The theory looks as is able to explain all observable forces and phenomena from one point of view. The unification is done based on one underlying field, so all observable fields and forces are emerge from that field. Main problem of ESTM-theory – cost of the unification. The unification is at cost of most core concepts of philosophy.

Only one assumption was done during writing of the theory. The assumption is postulate of ESTM-theory. Also, I did some guesses but none of them is critical for ESTM-theory. All processes which happen in emergent spacetime are considered by ESTM theory as atemporal processes.

In the article I described what ESTM-theory leads to $SU(3)$ symmetry as approximation, so it is possible to conclude that Standard Model can be approximate solution of ESTM-theory.

I described how to explain Special Relativity in ESTM-theory.

General Relativity is included into ESTM-theory, some changes to equations of General Relativity were proposed.

Main weakness of the theory now – lots of open mathematical questions. They need to be resolved to make the theory usable for calculations.

Another weakness of ESTM-theory – there are no analytical solutions of equations of ESTM-theory. I think it is quite expected, initially, for any hypothesis which goes beyond well-known area of gauge theories build on space of states. Equations of ESTM-theory are set of functional equations, so they are complex and not easy to solve.

Certainly, the proposed theory is very radical; it affects core concepts of philosophy. However, this theory is also promise radical reduction in number of independent phenomena. Occam's razor for this case shows the theory can be correct.

ESTM-theory proposes way to combine all known fundamental forces, including gravitation, within framework of ESTM-theory. In addition, ESTM-theory explains nature of time. This ESTM theory introduces only one new entity, scalar field of Metauniverse. I also propose method how, based on the field, it is possible to describe our Universe. The theory removes independent concepts of time, space and matter. Numerous magic constants, quantum mechanics and Standard Model contains many of them, is also expected to be removed during search for analytical solutions for equations of ESTM-theory.

ESTM-theory makes some changes in General Relativity in part related to cosmology, but probably there is no difference between FLRW metric and predictions of ESTM-theory after Universe becomes transparent to light. However, ESTM-theory proposes simple explanation of inflation phase of early Universe.

Loss of information after movement to another frame of reference is not observable; such observation is prohibited by super determinism of ESTM-theory.

Such problem, with small amount of new predictions, is mostly because ESTM-theory is compatible with Special Relativity, General Relativity and Standard Model. However, number of predictions may grow after deeper analysis of proposed equations of ESTM-theory.

Problem with observable predictions is not means that ESTM-theory cannot be falsified. ESTM-theory can be falsified if would be proven that equations of ESTM-theory have no solution satisfying all conditions mentioned above, or if solution of equations of ESTM-theory will be unable to correctly explain some phenomenon. ESTM-theory is candidate for Theory of Everything, so it should describe all physical phenomena under any physical conditions.

If ESTM-theory is valid, finding of equation of scalar field from our observable laws of physics would allow finding equations of particles, space and time from scalar field. As result, it can increase our knowledge of laws of physics and it would lead to measurable predictions, possibly it would result in discovering new phenomena.

List of predictions of ESTM-theory:

- ESTM-theory predicts what SU(3) symmetry is approximate. From point of view of observer in emergent spacetime, the approximation is close to precise for most energies, except probably Plank scale energies.

- ESTM-theory predicts what FLRW metric is incorrect at first moments after Big Bang.
- Parallel universes are predicted. Also, ESTM-theory predicts ability of interaction between some, but not all, parallel universes.
- ESTM-theory predicts that past cannot be changed, but not prohibit travel to past

Other results of the theory:

- ESTM-theory is able to explain General Relativity and Standard Model from one point of view and with usage of one only field.
- ESTM-theory propose changes to equations of General Relativity
- ESTM-theory propose way how to mathematically prove possibility of absence or presence of quantum gravity
- ESTM-theory contains theory of time as one of parts
- ESTM-theory proposed model of formation of spacetime, include model of formation of time and space during Big Bang. The theory describes formation phase, during the phase both time and space not existed, they were in process of formation
- Further development of the ESTM-theory, solving its equations, should allow looking even further before Big Bang, to where there was neither time nor space.
- New interpretation of Quantum Mechanic was proposed