A New Approach to Unification Part 4: Answers to open questions of actual physics

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In a series of 4 papers an approach to a unified physics is presented. In part 1 the foundation is given. In part 2 and 3 particle and gravitational physics are derived. In this 4^{th} part open questions of actual physics will be answered based on new interpretations becoming possible by the approach.

Contents

1 Introduction

Up to now it is shown that the unique root approach (UR) besides some extensions like the unification of forces looked for with GUT or the origin of black holes allows deducting the known results of 4d physics. To show that this is possible the common definitions of physical quantities had to be used. However, in order to answer the open questions of today's physics, also these definitions must be scrutinized.

In the following, the principles of UR are used to develop ideas that are compatible with the previous explanations of the physical phenomena and allow to overcome actually existing problems.

2 Separability

Like the sword of Damocles separability endangers the fundamentals of physics. It jeopardizes the possibility of physics at all. This seems to be nonsense as we do work with physics all the time but it is actually one of its big unsolved problems.

To show this we consider a simple experiment, the drop-test of Galilee. A ball falls in the gravitational field of the earth and its position as a function of time is measured. All this is to happen in a perfect arrangement with ideal vacuum and no error in measuring position and time.

If the measurement is very exact, making the experiment a second time, the result will be different. There are innumerable effects that cannot be controlled. The position of sun, moon and the planets, the weather, changes inside the earth . . . , all has an influence. And all these entities again are influenced by innumerable other effects and so on and on. In consequence this means that everything depends on everything.

This holism at the beginning of modern physics generated the fundamental question whether at all it is possible to separate things so that an experiment can give a meaningful result.

Newton overcame the problem with the postulate of separability and individuation. It says: Systems separated in space have an individual existence. The behavior of an assembly of such systems can be described by the features of the single systems. The air pressure of a gas e.g. can be attributed to the speed of its gas particles.

In practice it means that in any experiment a situation must be generated that allows differentiating between the main effect and unavoidable secondary effects.

The foundation of all physics is based on the possibility to generate experimental setups allowing to neglect the errors coming from the secondary effects or at least – by a thorough analysis of the processes – quantifying them. Today too in complicated experiments eliminating unwanted influences is a major task (not always succeeding at the first attempt).

For a long time it seemed as if the problems arising by holism were overcome by this procedure.

In actual physics holism however again is a very serious issue as some quantum physical states are not separable and thus seem to overturn the established fundamentals of physics. [1, 2]

It was Einstein who drew attention to the problem. As an argument for his critique on some aspects of quantum physics in 1935 he together with two colleagues set up a thought experiment, today called EPR experiment, with which they could show that quantum mechanics does not fulfill Newton's postulate.[3]

In an experimentally verifiable version formulated by Bohm [4] a molecule with zero spin emits two electrons (in other versions two photons). As the spin of the molecule is unaltered the state of the two particles in quantum mechanics is described by an entangled wave function, forming a new quantity with zero spin. It is not expressible as a product of individual wavefunctions but is instead a superposition of product states that cannot be separated in two single particle wavefunctions.

The spins of the two particles are opposite to each other but the orientation of each individual spin is unknown. The probability for each particles is 50 % for spin up or down regardless of which direction is measured.

Measuring now the spin of one particle in an arbitrary direction the wave function is reduced and the other particle is described by a one particle wave function with spin in opposite direction to the measured one. So measuring the second particle the result is predictable.

The question arises how the second particle that can be arbitrary far away from the first one is able to realize that a measurement and especially in which direction has taken place.

Einstein and his colleagues concluded from this behavior, that quantum physics does not give a complete description for the system, that it is incomplete. They took the view that there exist hidden variables that determine the spin of both particles already before a measurement, so that the above formulated question does not occur. This view means that they do not accept the entirety of the entangled wave function but demand instead a sometimes local realism called description based on separability and individuation.

Bohr in his answer on the (original) EPR experiment denies incompleteness of quantum mechanics and attributes its results to the specifics of measurement and as another prove of the novelty of the theory.

How important for Einstein his view was can be learned from two of his letters written in 1948 to Born.[5] In one Einstein writes (translation by the author): "...that, what we think to be existing (>is real<) in some way should be localized temporal and spatial. I.e. the real in a part A of space should (in theory) >exist< somehow independent of that what is thought real in another part B of space. If a physical system covers A and B then what is existing in B should have an existence somehow independent of what is existing in A. What is real existing in B so should not depend on which type of measurement in the part A of space is executed; it should also be independent of whether in A at all a measurement was done or not ... . Renouncing however the assumption that what is real in different parts of space has an independent existence I see not at all what physics is to describe."

In the next letter "...Characteristic for the relative independence of spatially distant entities (A and B) is the idea: external influence on A has no immediate influence on B ... . The complete cancellation of this principle would make the idea of the existence of (quasi)-closed systems impossible and with that make it impossible to devise an empirically testable law in the sense familiar to us."

A decision whether hidden variables as supposed by Einstein are acting or whether the entangled wave function is giving a correct description became possible when in 1963 Bell [6] devised its inequality saying that in a slightly modified EPR experiment the different approaches should show distinguishable results. As found in various experiments, e.g. given in [7], the result is unambiguous, quantum mechanics gives the right description.

This result brings us back to the question: how does the second particle know that the first one has been measured and what is the meaning of Einstein's arguments?

Howard analyzes the problems.[8] He finds that because of the shown non-separability none of the actual physical theories all based on Newton's postulate of separability and individuation can be used to generate a fundamental theory, even quantum mechanics is not appropriate: "Strictly speaking, the quantum theory of interactions implies that we should write down one grand nonfactorizable state function for the whole of the forward light cone of every event. Of course we do not do this, but we have no fundamental principle that justifies our ignoring this radical nonseparability of quantum states."

Within the scope of actual physics the divergent views of Bohr and Einstein on separability seem to be insurmountable. Nevertheless the effect is pragmatically exploited for technical applications without addressing the unresolved issues.

2.1 Bohr versus Einstein

As separation in space and time no longer can be used as an argument for separability and individuation a unified theory must find a new justification, it must reconcile the different views of Bohr and Einstein.

Discussing the EPR paradox in the frame of the new approach (UR) things are different. There are two new aspects:

1. the deductive approach. Physics is not developed starting from mechanics with its particles but is deducted from six dimensional (6d) physics. The best approximation to this target is given by the relativistic quantum physical equations. So interpretation of physics must start with the quantities they describe.

   By a more and more coarsened description other formulations of physical laws are found. This results in a hierarchy of description levels:

   6d Euclidean $\rightarrow$ 6d pseudo-Euclidean $\rightarrow$ 4d quantum physical relativistic $\rightarrow$
   4d quantum physical non-relativistic $\rightarrow$ classical.

   Only in the classical level physical events are accessible to our perception.
2. the subjective character of 4d physics. 4d physics does not describe reality but an image appropriate to our perceptivity.

   All our knowledge of physics in the higher levels of the description hierarchy are based on the interpretation of measuring results emerging on the classical level.

Trying to make the non-separability resulting from the Bell test experiments compatible with Einstein's demand of separability there is only one way to overcome the dissent. It was Einstein himself who in his second letter indicates a solution. “The complete cancellation of this principle would make ... it impossible to devise an empirically testable law.” Important is the “complete cancellation”. This means that to overcome the problem there must be found areas in physics where it holds and where not.

UR is able to define these areas. The two demands must refer to different levels of the just introduced hierarchy of description levels.

Einstein's statement that for us physics is only conceivable in connection with separability then means that processes in the quantum physical levels for us are not imaginable. In consequence the results of the Bell test experiments lay down that no theory is possible that describes these processes classically.

This is in accord with Bohr's view that in quantum physics no statement over the objects of the quantum theoretical mechanism can be given exceeding the prediction of probabilities and that only the stochastic results of a measurement for us are perceptible reality.

On the other hand a non-separable theory is not able to describe the perceptible events necessary for us to describe physics at all. The classical hierarchy level with its separability must exist as demanded by Einstein because it is the only one where the measured results of processes in the quantum physical levels emerge.

So both are right Einstein when demanding separability and Bohr when pointing out the novelty of quantum physics.

To some extent introducing a hierarchy of description levels also answers Howards's demand of a fully new physics based on non-separability. Large domains but not all physics can be non-separable as otherwise physics eludes our imaginative power.

The results of the Bell test experiments demand not an all-encompassing non-separability. They demand non-separability only for specific domains. The hierarchy of description levels allows defining these domains and describing their transitions.

2.2 Measurement

What Bohr's "results of a measurement" really mean is interpreted in different ways. The often used Copenhagen interpretation says that the transition from quantum physical to classical status in a measurement is achieved, if an observer takes note of it. Following the hierarchy of description levels interpretation however the transition happens during the measurement itself when the transition between the two hierarchy levels is accomplished.

Only the interaction of a quantum physical quantity with a classical individuated unit gives an evaluable result. So in a quantum physical experiment the use of means allowing a transition between the hierarchical levels is necessary. In many experiments this means an individuated "donator" detaching a portion of its wave function, an individuated "acceptor" incorporating the portion or parts of it, showing usually an effect generated by the encorporation, or an individuated "sensors", a combinations of an acceptor and a donator, giving an intermediate information of a quantum system.

The individuation of the quantum physical entities happening during interaction with an individuated sensor or acceptor generates the collapse of the wave function This transition creates the prerequisites that an observer can take note of it and gives the result required in the sense of Einstein.

The quantum physical measurement problem so expresses the transition from the non-separable to the separable hierarchy level. It makes "measurement" a very general event not dependent on a specific observer. We all are the observers as by this mechanism our surrounding as we can realize it is generated.

2.2.1 Schrödinger's cat

Schrödinger's cat is a somewhat macabre gedankenexperiment in which a cat and a deadly mechanism triggered by a radioactive element are together in a sealed box. If a sensor recognizes a radioactive decay it starts the mechanism which kills the cat immediately. It is a good example to demonstrate the new view of UR.

Because of the radioactive element a quantum physical description is necessary. The standard interpretation is that until somebody opens the box the system will stay in a mixed state in which the cat is both dead and alive. Different attempts to argue away this situation contradicting common sense were undertaken but always at least for a short time this mixed state remains.

With the new interpretation the paradoxon is solved very easily. The radioactive element and the sensor as the rest of the box including the cat are individuated. The part of the experiment that cannot be individuated is restricted to the spacetime segment between emission and absorption of a particle. For this time without individuation no reaction in the classical level occurs, i.e. the cat is alive. In the moment the acceptor incorporates the particle (portion) physics happens in the classical level and the cat is dead. The external observer can calculate the probability whether the cat is dead or alive but there never exists a state in which it is both.

2.3 Holism and particles

The Bell test experiments show that the entities of 4d quantum physical hierarchy levels are non-separable. The experiment is non-relativistic so for the relativistic quantum physical hierarchy level this is an assumption seeming natural.

The non-separability in these levels is reasonable as the behavior of any entity in the two inaccessible dimensions cannot be controlled. The wave function can overlap even if it is localized in 4d in different domains.

Only in the classical hierarchy level the description is coarse enough to allow separability.

If in the quantum physical hierarchical levels no separation is possible it must be assumed that the found equations describe the universe as a hole. The question arises then how the effects usually attributed to particles can be understood.

An explanation can be provided by the generalized Dirac equation basically introduced in part 2 of the series in section 1.4.1. The wave function solving it is characterized by the discrete quantum numbers associated with the seven Casimir operators. In a measurement process these discrete quantum numbers are found. If two systems separated in the classical hierarchy level are interacting an exchange happens that alters these quantum numbers by a discrete step.

Assuming for an example the spin as one of the quantum numbers. The quantum numbers of the wave functions in the two systems can be measured before and after the interaction. Each system will be in another state what means that its spin quantum number has changed. As we cannot observe the interaction process itself but only its results it is not known what happens during interaction. But an obvious assumption to explain the process is introducing entities carrying a spin equal to the observed change in the quantum numbers. The different spins in the two systems then becomes the result of exchanging these entities. But not the entities are basic but the quantum numbers. The entities are only an imagination of the unknown interaction process.

If there would exist an entity with a spin that does not fit to the steps possible in the spin quantum number of the generalized Dirac equation it would never be observed, so by convention it does not exist.

In addition to the discrete quantum numbers generated by the "inner" SU(8) symmetry conservation laws for the "external" symmetries for the entities hold.

The entities defined by the possible changes in the quantum numbers of the generalized Dirac equation usually are called particles. However they are not localized, neither point- nor string-like but only portions of the wave function and behave like this. The interpretation did switch from a particle with characteristics to the characteristics of the possible states allowed by the generalized Dirac equation.

So an electron is a portion of the global wave function occurring in interaction processes with the ability to change the spin of a wave function by $1/2$, its electric charge by 1 and its energy and momentum.

3 Interpretation of the wave function

The standard interpretation of a wave function was given by Born [9] understanding its moduli square as a probability density to find a particle in a given volume. There are alternative interpretations e.g. that of Bohm [10] assuming the wave function to be a pilot wave that guides a particle to a trajectory compatible with the results of the Schrödinger equation.

Both interpretations require the concept of particles adopted from classical mechanics. But particles are not a genuine entity in quantum physics. They are introduced there to generate the type of interaction known from mechanics.

In the quasi-classical limit, i.e. assuming $\hbar \to 0$, the moduli square of the wave function of the Schrödinger equation is proportional to the density of a classical liquid, [11] hence does not describe individual particles, but a continuum.

This connection motivated Schrödinger to interpret it as a matter density and his equation as describing a matter field. A detailed description of the physics of matter waves can be found in [12].

Since the physicists of these days were attached to the particle image his interpretation however was considered as untenable as the wave function of a single electron in a detector generates a single point and not a dissolved structure as its extended wave function suggests. Moreover its charged cloud was assumed generating a not observed self-interaction.

According to the above statements these arguments however are not valid.

1. As by an acceptor only integer entities carrying the correct value of the quantum numbers given by the Casimir operators in the generalized Dirac equation can be incorporated a portion of the matter wave e.g. carrying spin $1/2$ that is at a time in contact with several acceptors can interact only with one of them. This acceptor will incorporate the whole portion. The correct result is achieved assuming that the

probability of an acceptor to get the portion is proportional to the moduli square of the portion's wave function at the position of the acceptor.

Similar to Bohm's interpretation the aspect of probability here enters not by assuming the wave function to be a probability function but by assuming this selection criterion.

2. The expansion of a portion's wave function carrying one elementary charge cannot generate a self-interaction as only multiples of the elementary charge can interact. UR does not allow to conceive an idea of a spatial relation between wave function and charge.

So Schrödinger's matter wave seems to be feasible. This "matter" however only in its limit has the form of classical matter. All features of quantum physics are reflected in the matter wave.

A portion of the matter wave (or a "particle") that undergoes no interaction will expand unlimited in space. This is shown e.g. by the Schrödinger equation of an initially localized wave packet [13] but also by the Dirac equation [14]. The transition from the quantum physical hierarchy level to the classical one carried out by the interaction with a sensor or an acceptor localizes the expanded matter wave to its size in the sensor or acceptor.

This immediate change is characteristic for the transition to the classical hierarchy level.

To clarify the new interpretation some of the standard experiments of quantum physics are to be discussed.

3.1 De Broglie's box paradoxon

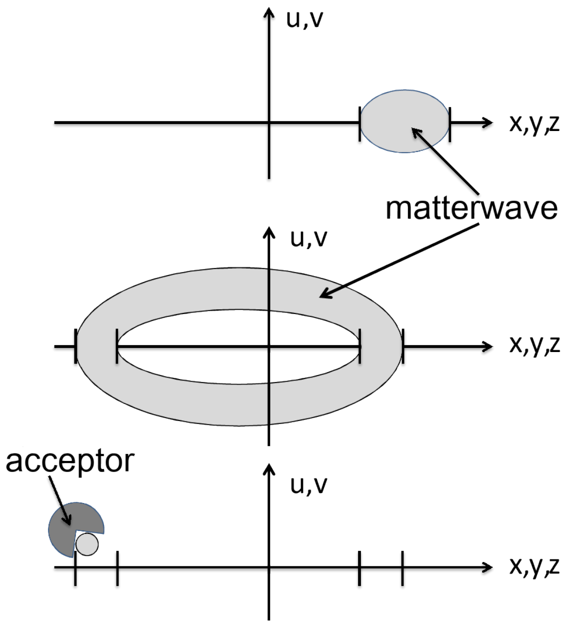

Figure 1: Stages of matter-density in de Broglie's box paradoxon

The de Broglie box paradoxon describes a gedankenexperiment in which a portion of matter wave e.g. an electron is inside a sealed box. The box in the middle is divided in two closed boxes that are brought to different places.

Omitting at first the u,v-axis of figure 1 it can be seen what happens during the experiment in three spacial dimensions. The short lines in the upper graphics indicate the sealed box at the beginning with the electron inside and by the two pairs of short lines in the middle graphics.

Following the usual interpretation of quantum mechanics this procedure means that in each box the same wave function describing a superposition of the two states: "particle in" and "particle not in" is given. Measuring now in one box whether the particle is in it or not the wave function collapses in both boxes, as shown in the lower graphics.

Trying to explain this behavior in the traditional interpretation gives the usual problems: How can the wave function in the second box know that a measurement is made in the first one?

With UR as shown by the full figure 1 the wave function of the considered portion never was separated as it represents an indivisible entity. This is possible because the two other dimensions cannot be controlled as indicated by the expansion of the matter wave in the u,v-direction in the upper and the bows connecting the two boxes in the middle graphics. In the assigned spacetime it remains connected all the time.

Measuring in one box an acceptor will incorporate the whole portion with 50 % probability. If yes, the wave function collapses to the place of the acceptor conveying the impression that a particle has been in the box, if not, it collapses to a wave function localized around the other box.

3.2 Double-slit experiment

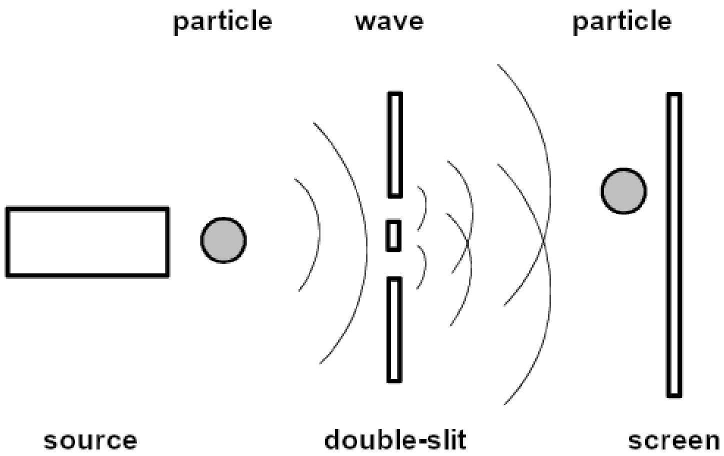

Figure 2: Double-slit experiment (standard interpretation)

The traditional explanation of the double-slit experiment is shown in figure 2. Electrons are emitted by a source (the arrangement allows emitting electrons one after another). At this stage the electron shows its particle character. Only by passing a double-slit it can reach a screen e.g. a photographic plate in some distance behind the slits. Passing the double-slit the electron shows its wave character. When reaching the screen again its particle character appears so that each electron emitted gives a single point on the plate. Repeating the measurement gives the pattern shown by the moduli square of a wave function generated by two interfering wave functions each passing one slit.

Explaining it with UR means: A donator (the source) emits a portion of its matter wave carrying spin 1/2 and an elementary charge. After being emitted the cloud of the portion expands according to Schrödinger's equation for free particles, passes through the two slits, the two parts of the waves interfere and one acceptor of the acceptor arrangement incorporates it. The probability to do this is proportional to the moduli square of the wave function resulting from interference. This explains single point and pattern.

Donator, slits and acceptors are classical and individuated. Information of what happens between donator and acceptor is restricted to what is given by the Schrödinger equation.

A modification of the experiment uses a sensor allowing to decide through which slit the electron passes. The result is a modified pattern. It now looks as if always the slit the electron did not pass through had been closed. Traditionally this is hard to explain.

UR allows explaining the effect as follows: As in the first case after being emitted the portion of the matter wave expands according to Schrödinger's equation for free particles, passes through the two slits and occurs with equal density behind each slit. Behind each slit a sensor is installed. Each of them can incorporate the full portion for a short while and then emits it again. (The type of sensor can be different. Its characteristic is its ability to individuate the portion.) One of the sensors will incorporate the portion and give a signal. The probability for each one is 50 %. This incorporation (or otherwise achieved individuation) can be understood as a short-time concentration of the wave function at the place of the sensor. Afterwards it again expands from the position of the sensor like the matter wave of a free particle (portion) giving the measured results.

A further modification of the experiment could be of interest: Measuring the spatial distribution of the donators that eject a portion in a mirror-symmetric arrangement with donators being spread over a plate like in the usual experiment the acceptors. It could give some insight in the next higher hierarchical level.

3.3 EPR experiment

As we have seen in section 2 interpreting the measuring result of the EPR experiment causes problems.

With UR the findings of the experiment can be explained assuming that there is one portion of the matter wave characterized by the quantum numbers of two entities. The cloud of the portion expands according to Schrödinger's equation.

The quantum numbers of the cloud allow that a sensor or acceptor takes an entity with the quantum numbers of a single entity out of the cloud what means that the cloud of another single entity with matching quantum numbers remains.

This means in detail: A detector (acceptor) able to measure spin direction and to absorb a portion carrying the spin of one constituent of the entangled wave function incorporates the respective part of the portion and shows the result. The rest of the portion gets by the measurement the opposite spin direction.

3.4 Bound states and muonic hydrogen problem

Bound states like a hydrogen atom or solid matter can be considered as the consequence of portions of the matter wave interacting with each other. The various portions don't dissolve as in the sense of quantum field theory they continuously interact by exchange particles. For each interaction the dissolving portions have to become localized. In the interaction of dissolving and contraction a stable state emerges.

The proton radius found in muonic hydrogen is different to that found in common hydrogen.[15] A puzzle for traditional physics. Different assumptions are made to explain this discrepancy questioning fundamental conceptions. Is it a experimental problem related to the muonic or proton sector, has the Rydberg constant to be modified or must the theory of bound-state QED be altered?

UR can offer an explanation of the two different radii. As the interactions between proton and electron or muon are different because of their different sizes the stable state generated by dissolving and contraction is different. This influences also the radius of the proton (primarily defined by the interaction processes of its internal structures).

4 Matter

In sections 2.1 of part 2 of the series it is shown that the "6d kinetic energy" in the two not accessible dimensions at the transition from 6d to 4d in the Lagrangian generates a mass term. It is initially defined by a Compton wavelength. Via the wave-particle dualism however it can also be attributed to a particle mass m_0. Introducing boundary conditions assuming that the wave functions in the not accessible dimensions are zero at the boundary of a rectangle with length l_u resp. l_v gives

$$m_0 = \frac{\hbar}{\lambda_C c} = \frac{\pi\hbar}{c}\sqrt{\frac{n_u^2}{l_u^2} + \frac{n_v^2}{l_v^2}}. \tag{1}$$

with eigenvalues $n_u = 1, 2\ldots$ and $n_v = 1, 2\ldots$.

This shows that particle mass depends on the wavelength or the area to which the location of a particle is limited.

This volume dependence of the mass of a particle occurs also in traditional quantum physics. To show this the principle of conservation of energy $m^2c^4 = p^2c^2 + m_0^2c^4$ and Heisenberg's uncertainty principle $p^2 \geq \frac{\hbar^2}{d^2}$ are combined. Here d is the diameter – e.g. for a bound electron that of an atom – of the space occupied by a concentrated unit, m its mass, m_0 its rest mass and p its momentum.

Eliminating the momentum gives

$$m^2 \geq \frac{\hbar^2}{d^2c^2} + m_0^2 = \frac{\hbar^2}{d^2c^2} + \frac{\hbar^2}{\lambda_C^2c^2}\ , \tag{2}$$

It can be seen that particle mass is a combination of rest mass and a volume-dependent mass. As the formula contradicts the idea of a particle in the conventional sense, it is usually given little attention.

Rest mass and volume dependent mass have the same structure. Both masses grow in the same way if their diameter becomes smaller. The Compton wavelength enters the inequality in the same way as the common wavelength. This behavior is an expression that the free 6d wave function has the same expanse in all five spatial dimensions.

The matter wave interpretation given in the last section describes these characteristics. For the matter density $\rho = C\psi\psi^*$ only the total matter $\int_V \psi^*\psi d\tau = N$, where V describes a volume that contains the entire cloud, is constant. C respective N are constants resulting from the homogeneity of the equations of motion. If ρ is interpreted as mass density, then N is the total mass of a cloud. If the wave function describes a single particle N equals its mass.[12]

Question arises why the variable particle mass occurring already in traditional physics is not observed. The answer lies in the measurement procedure of particle mass. The found dependence of mass of a particle or a portion of the matter wave cannot be measured without a sensor or an acceptor that individuates the matter wave at least for the moment of measurement. The concentrated volume of the portion then defines its mass.

A common experiment to determine the mass of an electron consists in a glass bulb filled with a little amount of noble gas in which an electron beam forced by electromagnetic fields moves at a circled track. Electrons colliding with gas atoms generate a luminous ring whose radius allows calculating electron mass.

But what is measured in doing so? The luminous ring is the result of a multitude of interaction processes between the cloud of a free electron and an electron of the atomic shell. During the interaction process the cloud of the free electron for a moment is implemented in the shell. The volume it then has defines the measured mass.

As although other measurement procedures of electron mass mean implementing it in the shell of an atom they all give the same result.

This is another feature generating the impression of particles.

Taking up the puzzle of proton radius of the last section this means: as the proton radius measured in muonic hydrogen is smaller than in hydrogen its mass should be larger.

4.1 Dark matter

Dark matter is an mysterious invisible entity expressing itself only by gravitation. It is a parameter in the cosmological model necessary to allow adaption to the observations.

In spite of an intensive search for its constituents they are still unknown. Various hypothetical particles have been searched in vain for decades in a multitude of projects:
– WIMPs (weakly interacting massive particles) associated with particles required by supersymmetry. Neither the XENON1T project in the Gran Sasso nor the PandaX project in Jinping with their huge underground laboratories could find any signal indicating WIMPS.[16, 17].
– Axions introduced in 1977, to solve the suspected CP symmetry problem in quantum chromodynamics. The search of the ADMX collaboration [18] or the ALPS project have not yet led to success.
– Sterile neutrinos. The search for sterile neutrinos might have come to an end as the effect on which the hypothesis for their existence is based on has broken away.[19, 20]

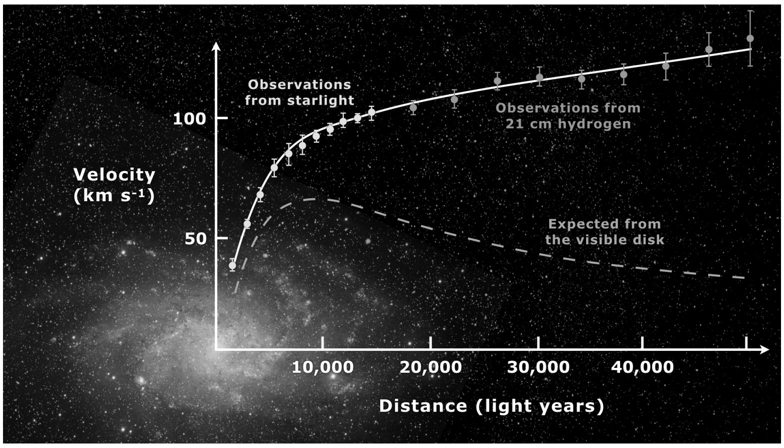

Figure 3: Rotation curve of spiral galaxy (from Mario De Leo in Wikipedia)

An observable feature usually explained by dark matter are the rotation curves of the outer stars in galaxies. The upper curve in figure 3 is a plot of the orbital speeds of visible stars and gas in an old galaxy versus their radial distance from the galactic center. It shows a completely different speed behavior than the one shown in the curve below, derived by applying Newton's gravity theory to the matter observed in a galaxy.

This demonstrates that an attractive force larger than the gravity generated by the visible matter must act. One approach to explain the variance is based on dark matter that surrounds like a big cloud the whole galaxy.

Actual observations show that for near, what means old galaxies the measured increase in rotation velocity is as shown by the upper curve whereas for galaxies far away, i.e. young ones the observed speed decreases as shown in the lower one.[21]

In the large-scale structure of the universe the galaxies form filaments enclosing immense voids. Investigations in which the gravitational effect of dark matter is analyzed show that it is concentrated along the filaments and is especially dense in the areas where in the honeycomb-like structure galaxies are concentrated.[22]

The interpretations of UR describing the wave function as a matter wave and the volume integral over its absolute square as particle mass opens a way to explain what the constituents of dark matter are, why they are invisible and how the distribution of dark matter emerges.

We have seen that matter waves tend to expand and are forced to concentrate by interaction. A portion of the matter wave that undergoes no interaction will expand with the speed of light unlimited in space. The density of the matter wave decreases but its total mass remains constant. As with time the physical dimensions of any sensor becomes very small compared to the size of the cloud built by the "particle" and as the cross section of an interaction depends on the density of the matter wave at the position of a sensor the probability that an interaction takes place goes to zero. So the expanding "particles" slowly become invisible and act only by their gravitational features.

Gravitation does not produce the type of interaction necessary for the concentration of the matter wave as it is not a force in 6d so that there does not exist something like an exchange particle of gravitation.

In a galaxy and even more in a galaxy cluster constantly an immense number of portions of matter wave is emitted. In the areas of dense matter interactions happen what often is accompanied by light emission. "Particles" not interacting for some time expand and the probability of an interaction sinks but is not yet zero. Occasionally light is emitted. This could explain the halo. If still no interaction happens the cloud becomes so large that the probability of an interaction goes towards zero. The matter wave becomes invisible.

This behavior perfectly describes the observations. Old galaxies are surrounded by a cloud of dark matter whereas in young galaxies this cloud had not yet the time to develop. Also the concentration along the filaments follows.

As dark matter does interact only very little with the stars of a galaxy that are much smaller than its clouds it generates no braking effect.

Trying to observe dark matter will always fail as if a seldom interaction happens a known particle will occur.

5 Concept for a new cosmology

Today the Lambda-CDM model is regarded as the standard model of cosmology. It describes the development of an accelerated expanding universe consisting of common and dark matter. Its name tells the main inputs: Einstein's equation with a cosmological constant Λ and besides ordinary matter also hypothetical cold dark matter. It is also called Big Bang theory as it assumes a starting moment of the 4d universe.[23]

Einstein had the idea of a static universe. The realization that general relativity describes an non-static universe led him to introduce the cosmological constant Λ in his equation to counterbalance the effect of gravity.[24] Its value decides whether the universe expands, contracts or is static. When by observing the cosmological redshift – which was interpreted as Doppler effect generated by the movement of the observed objects – it seemed obvious that the universe expands he withdrew the introduction of the coefficient. Much later when the increase of redshift of far distance galaxies was discovered and interpreted as accelerated expansion of the universe the constant was introduced again as a source of dark energy.

When Einstein introduced the coefficient it was related to the Einstein tensor, now it is understood as part of the energy momentum tensor and interpreted as the energy density of the vacuum.

The Lambda-CDM model uses a solution of Einstein 's equation for a homogeneous, isotropic and accelerated expanding universe. The cosmological findings are supplemented by the results of particle physics.

To adapt it to observations 6 (some say 7) parameters are used. It allows explaining the large-scale arrangement of the galaxies, the life cycles of stars, the formation and frequency of chemical elements, the existence and structure of the cosmic microwave background and the accelerated expansion of the universe.[25]

Using the cosmological constant to explain the acceleration causes problems. The evaluation of data collected by the Planck space telescope provides a value for the constant. On the other hand, it can also be calculated from the quantum fluctuations of the vacuum. The problem is that the two results differ by 120 (others say 60) powers of ten.

So acceleration is attributed to an unknown dark energy. Some try to explain it with an ad hoc introduced scalar field called quintessence. But also this approach fails because the particles associated with the field must have an extremely small mass and cannot be found.

Hard to explain is why in an expanding universe the structure of the galaxies is unchanged. The configuration of their solar systems should follow the expansion but they have the same shape and size regardless of how far they are away from us.

An important extension of the theory is a phase in the development of the universe called "inflation", an extremely short period of time in the early phase of its formation during which its volume increased dramatically. The expansion took place at a multiple of the speed of light. It assumes that quantum fluctuations in the microscopic universe before inflation are the seed for the structure of the universe what allows answers to several open question in the Lambda-CDM cosmology, as the flatness or the horizon problem.[26]

As cause of inflation a scalar field is assumed. Initially, it was tried to use the Higgs field for this purpose, but since this led to inconsistencies, a separate inflation field was introduced.[27]

Linearizing the Einstein equation an inhomogeneous wave equation can be derived. This allows solutions with wave character. Gravitational waves mean that the metric oscillates. The inhomogeneity shows that accelerated masses as e.g. of binary stars are the source of the waves that propagate as waves outward from their source at the speed of light.[28] Deriving this type of equation from the full Einstein equation is still pending. One of the reasons for this is that there exits no solution for a double star based on general relativity.

5.1 Metrics of transition

Up to now UR deals with rather realistic events. As shown above, cosmology is much more speculative. This holds also for UR.

The basic idea of UR is that the transition from the timeless 6d Euclidean space to the 6d assigned spacetime is a dynamic but continuous process and that the metric of the assigned spacetime derived in equation (8) of part 3 of the series with coefficient not dependent on time (here given in its isotropic form)

$$ds^2 = -dT^2 + dr_5^2 \tag{3}$$

gives its final state.

For the beginning of the universe we can make only rather vague assumptions. One is – as we cannot emphasize any direction of the assigned spacetime in its statu nascendi – that it has spherical symmetry and isotropy. Because the only variables of which we have an idea are T and r_5 as given by their differentials in equation (3) to be able to describe the unknown process of formation we must demand that it is associated with them. The following postulate serves to achieve this.

UR Postulate 6. There are two functions Θ and Π depending on temporal and spatial features that allow connecting the Euclidean space and the assigned spacetime. The two functions are unknown but can be expressed in the variables T and r_5 they finally become. For large T it holds $\Theta \to T$ and $\Pi \to r_5$, $\frac{d\Theta}{dT} \to 1$, $\frac{d\Theta}{dr_5} \to 0$, $\frac{d\Pi}{dT} \to 0$ and $\frac{d\Pi}{dr_5} \to 1$.The temporal component is characterized by constant increase.

The postulate allows defining a metric in the coordinates of the finalized assigned spacetime with metric coefficients dependent on differentials of the unknown functions. This metric finally at a fix local position will get the form given in equation (3).

With $d\Theta = \frac{\partial\Theta}{\partial T}dT + \frac{\partial\Theta}{\partial r_5}dr_5$ and $d\Pi = \frac{\partial\Pi}{\partial T}dT + \frac{\partial\Pi}{\partial r_5}dr_5$ we get for the early assigned spacetime

$$ds^2 = -\left[\left(\frac{\partial\Theta}{\partial T}\right)^2 + \left(\frac{\partial\Pi}{\partial T}\right)^2\right]dT^2 + \left[\left(\frac{\partial\Theta}{\partial r5}\right)^2 + \left(\frac{\partial\Pi}{\partial r5}\right)^2\right]dr_5^2 + 2\left(\frac{\partial\Theta}{\partial T}\frac{\partial\Theta}{\partial r_5} + \frac{\partial\Pi}{\partial T}\frac{\partial\Pi}{\partial r5}\right)dT dr_5.$$

How these functions have to look like is not known. They can be chosen in a way that allows describing correctly the physical phenomena in the formation of our universe.

One trial gives the metric

$$ds^2 = -\left[\frac{\Theta^2}{\Theta^2 - \Pi^2} - \frac{\Theta^2\Pi^2}{(\Theta^2 - 2\Pi^2)^2}\right]dT^2 + \left[\frac{\Theta^4}{(\Theta^2 - 2\Pi^2)^2} - \frac{\Pi^2}{\Theta^2 - \Pi^2}\right]dr_5^2 - 2\left[\frac{\Theta^3\Pi}{(\Theta^2 - 2\Pi^2)^2} - \frac{\Theta\Pi}{\Theta^2 - \Pi^2}\right]dr_5 dT. \tag{4}$$

It can be seen that the metric coefficients depend only on $x = \frac{\Pi}{\Theta}$. This makes the metric in some sense scale independent.

Introducing x gives

$$ds^2 = -\left\{\frac{1}{1 - x^2} - \frac{x^2}{(1 - 2x^2)^2}\right\}dT^2 + \left\{\frac{1}{(1 - 2x^2)^2} - \frac{x^2}{1 - x^2}\right\}dr_5^2 + \left\{\frac{2x}{1 - x^2} - \frac{2x}{(1 - 2x^2)^2}\right\}dT dr_5. \tag{5}$$

In the T, r_5 space x is a parameter. For $x = 0$ from this metric the metric of the assigned spacetime given in equation (3) follows.

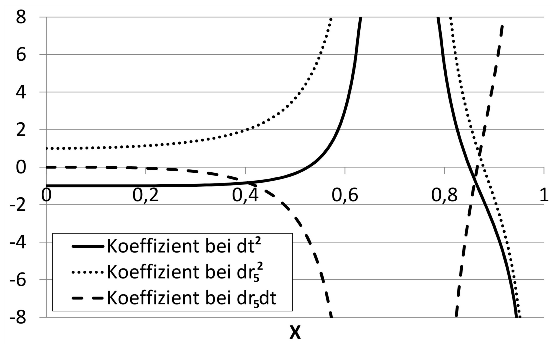

Figure 4: Metric coefficients

As shown in figure 4 the coefficients of the metric behave quite wildly with poles and changing signs. The interpretation is further complicated by the non-diagonal term with $dTdr_5$. Only for $x < 0.4$ the metric approaches that of the assigned spacetime. Then the first term of equation (5) can be interpreted as a time-like coefficient, the second one as space-like and the mixed one begins to vanish.

So with an increasing Θ for a rather constant Π it will result $\Theta \gg \Pi$, what means $x \to 0$.

Because of the complicated structure of this early metric the transition to 4d as given in part 3 of the series in detail is still pending. That makes it necessary to conduct the investigation in the assigned spacetime. Exact information about the emergence of mass and gravity so are not yet obtained.

The mixed term of the metric can be eliminated by introducing rotated coordinates. With

$$\begin{pmatrix} dT \\ dr_5 \end{pmatrix} = \begin{pmatrix} \cos(\alpha) & -\sin(\alpha) \\ \sin(\alpha) & \cos(\alpha) \end{pmatrix} \begin{pmatrix} d\zeta \\ d\eta \end{pmatrix} \tag{6}$$

we get for the rotation angle α

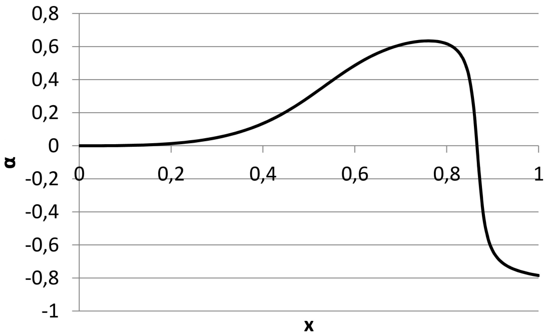

Figure 5: Angle α diagonalizing the metric as function of x

$$\tan(2\alpha) = \frac{\frac{2x}{(1-2x^2)^2} - \frac{2x}{1-x^2}}{1 + \frac{1-x^2}{(1-2x^2)^2}}. \tag{7}$$

As shown in figure 5 the coordinate system turns from $x = 1$with decreasing x in the direction of larger angles. $x \approx 0,865$ leads to $\alpha = 0$. The maximal positive angle of $\alpha \approx 0,632$ is given for $x \approx 0,744$. With x further decreasing x also the angle decreases and approaches zero.

For $x \to 0$ we find $\cos(\alpha) \to 1$ and $\sin(\alpha) \to 0$ so $d\zeta \to dT$ and $d\eta \to dr_5$. For $x \to 1$ it holds $\alpha \to -\pi/4$ what means $d\eta \to \frac{\sqrt{2}}{2}(dT + dr_5)$ and $d\zeta \to \frac{\sqrt{2}}{2}(dT - dr_5)$.

This means that also the diagonalized metric with increasing T leads to the metric given in equation (3)

5.1.1 Zero-geodesic

For $ds^2 = 0$ the zero-geodesic follows. In 4d it describes the propagation of light. In a spherical isomorphic system this is also the expansion of space. The expansion speed of the assigned spacetime is the same as that of our universe, its submanifold. So the results found with $\frac{dr_5}{dT}$ also hold for the speed of light in 4d.

We find the relation

$$\frac{dr_5}{dT} = \frac{\frac{x}{(1-2x^2)^2} - \frac{x}{1-x^2}}{\frac{1}{(1-2x^2)^2} - \frac{x^2}{1-x^2}} + \sqrt{\left(\frac{\frac{x}{(1-2x^2)^2} - \frac{x}{1-x^2}}{\frac{1}{(1-2x^2)^2} - \frac{x^2}{1-x^2}}\right)^2 + \frac{\frac{1}{1-x^2} - \frac{x^2}{(1-2x^2)^2}}{\frac{1}{(1-2x^2)^2} - \frac{x^2}{1-x^2}}} \tag{8}$$

shown in figure 6.

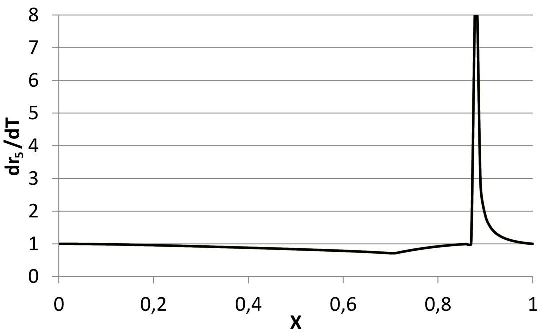

Figure 6: Speed of light as function of x

For $x > 1$ the expression is complex. The left-hand limit $x \to 1$ gives $\frac{dr_5}{dT} = 1$. With decreasing x the value of $\frac{dr_5}{dT}$ is continually increasing and culminates in a pole at $x \approx 0,884$. After the pole $\frac{dr_5}{dT}$ falls very fast to 1, declines til $x = 1/\sqrt{2}$ gently to $1/\sqrt{2}$ and increases for smaller x hugging the value $\frac{dr_5}{dT} = 1$ that is reached for $x = 0$.

The metric given in equation (5) can be written as

$$ds^2 = -\frac{(dT - xdr_5)^2}{1-x^2} + \frac{(xdT - dr_5)^2}{(1-2x^2)^2} = -\frac{dT^2(1 - x\frac{dr_5}{dt})^2}{1-x^2} + \frac{dT^2(x - \frac{dr_5}{dt})^2}{(1-2x^2)^2}.$$

In this form looking on the point $x = 1$ in more detail is easier. We find: As for $x = 1$ it holds $\frac{dr_5}{dT} = 1$ the second term vanishes and it holds

$$\lim_{x\to 1} ds^2 = \lim_{x\to 1} -\frac{dT^2\,(1-x)^2}{1-x^2} = 0$$

So the universe at its beginning is point-like and increases with c, the speed of light as we know it. That $\frac{dr_5}{dT}$ for $x > 1$ is complex shows that these states cannot be expressed in real variables r_5 and T. $x = 1$ characterizes the transition happening in one point of the Euclidean space forming the nucleus of a new metric. For $x \lessapprox 1$ we get $ds^2 = -\frac{(dT - xdr_5)^2}{1-x^2} \approx -\frac{2}{1-x^2} d\zeta^2$, something like an absolute difference metric in a one dimensional time-like space or just the expansion of the diagonalized coordinate. This is still a metric, the pseudo-metric of the assigned spacetime develops only for $x < \frac{1}{\sqrt{2}} \approx 0,707$, the position of the second pole in the metric coefficients.

5.2 Explaining cosmic effects

5.2.1 Inflation

Following the behavior of $\frac{dr_5}{dT}$ we see, that after the beginning the tiny assigned spacetime starts to expand at first with the speed of light as we know it and then with decreasing x faster and faster. For a very small range of x the speed grows beyond all measure to fall back abruptly afterwards.

The pole and its fast end can justify the inflation of the early universe.

5.2.2 Generation and distrubution of matter in the universe

The assigned spacetime is expanding with the found speed of light. Because of the close relation between the 6d Euclidean space and the assigned spacetime given by UR this expansion is not free. It has to replicate the structure of the Euclidean space, especially its local symmetries. If such a symmetry is spherical this must also be true for the assigned spacetime what leads in 4d to an attractor as given in part 3 of the series in section 2.1.2.

The attractors are the nuclei for the accumulations of matter in the universe. Their positions are not influenced by the expanding assigned space but remain at their position defined by the symmetry of the timeless 6d space. The stars and galaxies in our universe therefore do not follow the general expansion of space but retain in their positions. This explains why the shape of the galaxies is not changed by the expansion of the universe.

The consideration does not take into account the slow movements that arise due to the momentum and the gravity of the masses formed during the transition to 4d. So the matter in the universe is immobile only over long distances.

5.2.3 Isotropy of cosmic microwave background

Comparable to Huyghen's principle one can assume that each central point of a local spherical symmetry in the Euclidean space is the nucleus for another source of expansion, so that the assigned spacetime becomes the overlay of many such sources placed at different positions.

Following the result of the standard model the generation of our universe generates electromagnetic radiation that can be observed nowadays as rather isotropic microwave radiation.

This holds also for UR: As in the standard model the expanding 4d universe is the carrier of light and the expansion increases its wavelength. The isotropy and minimal variation of the background radiation with UR however follows from its creation in a huge number of statistically distributed sources.

5.2.4 Trigger of gravity waves

Since the assigned spacetime is continuously expanding it also happens nowadays that new attractors are generated. The associated sudden appearance of a gravitational field could be the origin of gravitational waves.

5.2.5 Cosmological redshift and dark energy

As the positions of the stars in 4d is not subject to the expansion of spacetime a novel explanation of cosmological redshift is required. Due to the equality of the 4d speed of light and the expansion speed of the assigned spacetime, this investigation can be carried out in 4d.

1. The speed of light decreases from the final level with $x = 0$ to $x = 1/\sqrt{2}$ from c to $c/\sqrt{2} \approx 0,707c$.
2. So light we see from distant stars long ago was produced when speed of light was lower.
3. The energy of light is equal to the energy difference between two energy levels in e.g. atoms. This energy – as coming from the original SU(4) force – does not change in time.
4. Light produced by the distant star has the energy $E = \frac{hc(x)}{\lambda(x)}$. If E =const and the speed of light increases on its way to the earth also λ must increase what generates an increasing redshift for stars with increasing distance.
5. As near $x = 0$ it holds $\frac{dr_5}{dT} = 1 - \frac{3}{2}x^2$ the decrease in speed becomes more and more pronounced with increasing x. It seems as if the redshift becomes stronger for light coming from far distant galaxies what in the common explanation means accelerated movement and dark energy.

   This holds til $x \approx 0.7$. For further increasing x also the speed increases, what means that if stars correspondingly old exist, their redshift is reduced with age.
6. The dark energy used to explain the accelerated expansion of the universe, understood as an unknown form of energy, does not exist. Not the velocity of the stars changes, but the propagation velocity of light.

5.2.6 Energy conservation theorem

The question arises where the energy required for the generation of the mass in the 4d universe comes from. Guth [27] points out that gravitation represents a negative energy. To compensate the gravitational field of an attractor the energy theorem therefor demands the same amount of positive energy, what means mass, to be generated. This could mean that the energy of the whole universe is zero.

6 The Theory of Everything

If anything can be called a ToE it is the full 6d Lagrangian in a 6d Euclidean space with a proper symmetry that generates in 4d our universe.

In the previous parts of the series, particle and gravity physics were derived from this equation. They are two facets of the overall picture resulting from the respective restrictions imposed. To find a ToE these restrictions must be dropped.

Starting e.g. with spherical symmetry of the timeless 6d space and a Minkowski type assigned spacetime following the procedure introduced in part 1 of the series this would mean

1. Formulating the 6d Lagrangian in the spherical coordinates of the assigned spacetime, solving its equation of motion, implementing the found solutions into the non-interpretable Lagrangian and integrating over the two dimensions not accessible in 4d.
2. Adapting a most general 4d Lagrangian (with all forces in their specific structures and mass terms and metric coefficients as adaption parameters) in 4d spherical coordinates to the non-interpretable Lagrangian found in 2. to get an interpretable Lagrangian.

Assuming the huge mathematical problems can be overcome, a unified 4d physics will be deducted. A solution should generate new effects by combining gravity with the other forces. Considering however the great effort required for such a solution, the expected result probably is rather meager. The different strengths of the forces should generate effects relevant only for high gravity. It can be estimated that they become significant when the gravitational potential acting on the mass of an electron approaches the electric one in hydrogen. If our sun would be point shaped this gravity would occur in a distance of about 5500 km.

It is more interesting to regard the situation with a developing assigned spacetime. For the price of even greater efforts, open questions as

- How does the propagation of the evolving assigned spacetime proceed in detail, taking into account its coupling with the timeless 6d space? What does this mean for the generation of the 4d universe? Are e.g. galaxies the result of vortices in the dynamics of the expanding assigned spacetime?
- How does the 3 forces of 4d physics develop from the SU(4) force of the timeless 6d space?

could be answered.

This is not an easy task, but one that can be solved, at least in principle.

But even if everything is solved the ToE will never be a theory of everything. Nearly all physical systems are chaotic. They are characterized by the feature that immeasurably small changes in the initial conditions can generate deviations in any scale of the future event. No theory will ever be able to predict in spring when a growing leave will fall.

The great value of a ToE does not lie in its ability to make predictions but in providing a uniform foundation of the physical principles of our world.

A final word: Elaborating a comprehensive approach to find a new understanding of physics as given in the four articles of the series is a rather daring enterprise. So as Newton did in his Principia I would like asking the reader to take the statements unbiased to heart, not to concentrate on eventual shortcomings but to help resolving them. If you have comments or questions to the article you are welcome to contact me under toeapproach@gmail.com.

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