

THE EXCLUSIVE
HIGHER-DIMENSIONAL
THEORIES OF
FUNDAMENTAL
MEMBRANE MODELS

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SCIENTIFIC POPULAR ARTICLE

MEMBRANE THEORY

ADVANCED TOPICS IN THE
MODERN THEORETICAL
PHYSICS

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Introduction

In the present popular scientific article are exhibit the applications of various supersymmetric quantum, gravitational and string theories in the context of different extensions with fundamental membrane models. We examine models directly related to membrane universes and a wide range of direct applications of the contemporary theoretical and mathematical physics in its various manifestations, realizations and shapes. Deeply presented is the current state of theoretical fundamental knowledge regarding the most developed conceptual models of physics beyond the standard model and various forms of theories of everything. The report deals with theoretical interventions for the physics of dark matter and energy, the physics of supersymmetric black holes, quantum wormholes in diverse dimensions, plus presented are also hidden symmetries in higher dimensions theories in combination with new models of specific types of membrane universes. We have reviewed the concept of supersymmetric black holes as it arises under conditions of supergravity and superstrings in diverse spacetime dimensions. We present different supersymmetric membrane solutions of eleven-dimensional supergravity with special realizations of the highly extreme areas of superstring theory, M-Theory and F-Theory. The paper shows that we have advanced interpretations of the supergravity transformations plus superstring interactions on a supersymmetric black hole and quantum wormhole solutions, with the possibility that suitable combinations of these transformations in the higher-dimensional interactions directly give rise to the membrane models constructions and interpretations. Very interesting aspects that we consider here is the possibility of sustaining quantum traversable wormhole spacetimes via exotic matter made out of phantom energy. The fact that phantom energy can be the

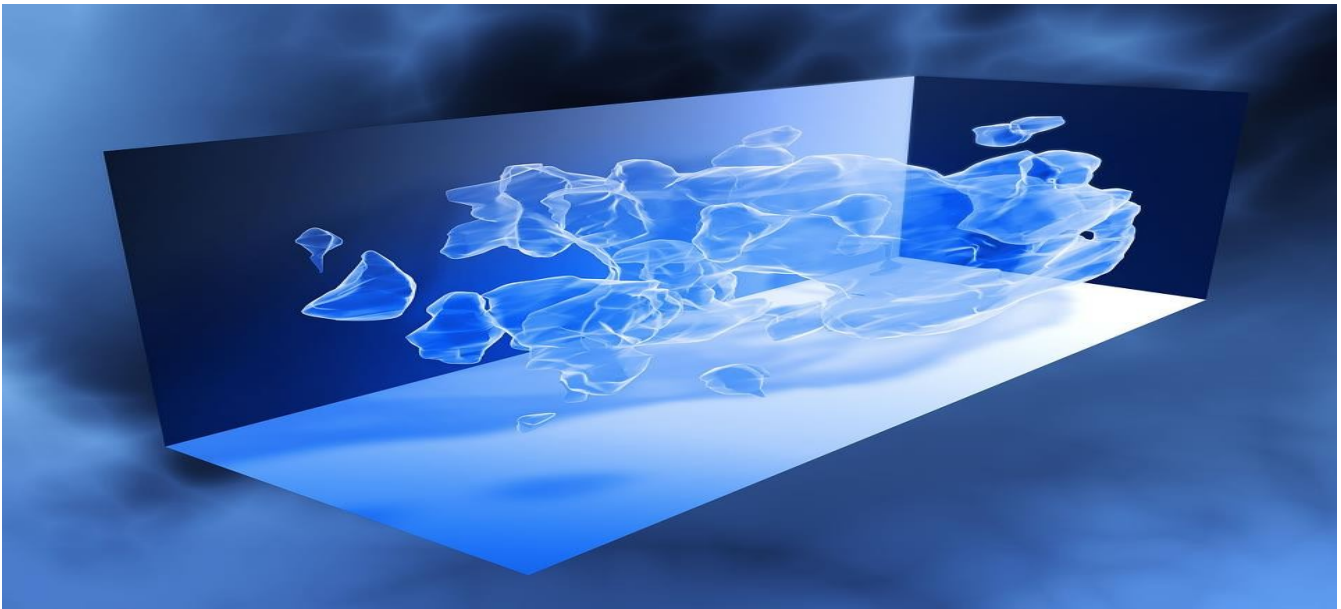
source of quantum wormholes is more than exciting, and give rise to investigate about the existence of stars and galaxies made of this kind of exceptional phantom matter. The present article investigates the possibility and naturalness of expanding wormholes in higher dimensions which is an important ingredient of the modern theories of fundamental physics, such as superstring theory, supergravity, membrane theory and many others special theoretical investigations. The many universe system in quantum cosmology can describe either the multiverse made up of different parent universes or the spacetime landscape formed by the new type of baby universes. The special feature of higher-dimensions which is useful for the study of baby universes is that some models admit their interpretation as supergravity and superstring theories in higher dimensional curved superspace. The theory find exclusive sources of interactions between different baby universes, for any higher-dimensional surface of the curved spacetime in the multiverse hyperspace. The behaviour of baby universes has been an important ingredient in understanding and quantifying the superstring theory and equivalently the models of higher-dimensional supergravity coupled to matter interactions of different supermultiplets in higher-dimensional supermanifolds and superspaces. The theory allows for the existence of many parallel universes where the laws of nature are slightly different from ours and describe another type equations. We have shown that mirror universes can provide a significant contribution to the energy density of the multiverse, and thus they could represent the component of dark matter and dark energy making up the special type of mirror universes with their fundamental interactions. The significant breakthrough and interpretations with the sense over theories in higher dimensions and the victory of the theory of hyperspace in the identification and examination of higher dimensions of spacetime. The article examine the multiverse of a somewhat different kind envisaged in the supergravity, superstring theory and their higher and elegant

extension M-theory. These theories require the presence of ten or eleven spacetime dimensions respectively which elegant give rise to the more fundamental theory of multiverse. In the membrane theory our universe and others are the result of collisions between membranes in eleven dimensional spacetime. The membrane theory allows for the consideration of many different internal spaces in hyperspace - as much as a huge number of different parallel universes exist, interact and swim in the multiverse with its own special set of laws of nature and different physics.

The Dark Matter and Dark Energy in Higher-Dimensional Models of Supergravity, Superstrings and Fundamental Membranes

In the exceptional theoretical framework of higher-dimensional supergravity and superstring theories, were the first attempts to describe dark matter and dark energy through quintessence and perfect examples of models designed to describe the dark side of the universe with additional fundamental membranes. We are interested in the coupling between matter, baryonic or dark with the current interactions, and dark energy in the context of particle physics models connected to the theoretical high energy physics and quantum cosmology. More precisely, we shall be concerned with supersymmetric models in diverse dimensions beyond the standard model of particle physics. Moreover, models of dark matter and dark energy were embedded in supergravity and superstrings in the different publications. The fundamental motivation for introducing supersymmetry remains the argument that theories describing physics over an energy range of many decades must incorporate supersymmetry in order to remain technically natural. It is worth iterating the details of this technical naturalness, which we will do shortly. Further motivation derives from the observation that a combination of supersymmetry transformations gives a spacetime transformation, so that theories of local supersymmetry necessarily

contain local spacetime transformations, and thus they contain gravity. It remains an open problem to construct a viable theory of elementary particle physics which contains gravity, but much can be said in the context of supersymmetric theories. Our system of winding and momentum modes is described by nonequilibrium dynamics due to the expanding background spacetime. All the information about the evolution of these modes will be contained in the effective type of interactions. Supersymmetry is usually assumed to be broken in a hidden sector. In the following, we will concentrate on the possibility that the breaking of supersymmetry is transmitted to the standard model via gravitational interactions. The coupling dark energy to supersymmetry breaking modifies runaway potentials in a drastic way, giving a large mass to the quintessence field of order of the gravitino mass. This can only be avoided using no scale models. In this case, only very special superpotentials can lead to a chameleon effect, and therefore viable models. The construction of such models is challenging and worth pursuing. We embed models of holographic dark energy coupled to dark matter in minimal supergravity plus matter, with one chiral superfield. We analyze two cases. The first one has the Hubble radius as the infrared cutoff and the interaction between the two fluids is proportional to the energy density of the dark energy. The second case has the future event horizon as infrared cutoff while the interaction is proportional to the energy density of both components of the dark sector. Regarding the low-energy limit of superstring theory, supergravity is a natural option to investigate if it can furnish a model that describes the accelerated expansion of the universe, where the canonical scalar field plays the role of the dark energy. However, since supergravity with four supercharges exists in four dimensions at most in higher dimensions such as in superstring theory one needs more supersymmetries for the higher-dimensional supergravity constructions. Supergravity theories in diverse dimensions play nowadays an important role as low-energy effective field theories of superstring and membrane theories. Explicit knowledge of this set of theories gives us a powerful tool for exploring the connection between string theory and low-energy physics.

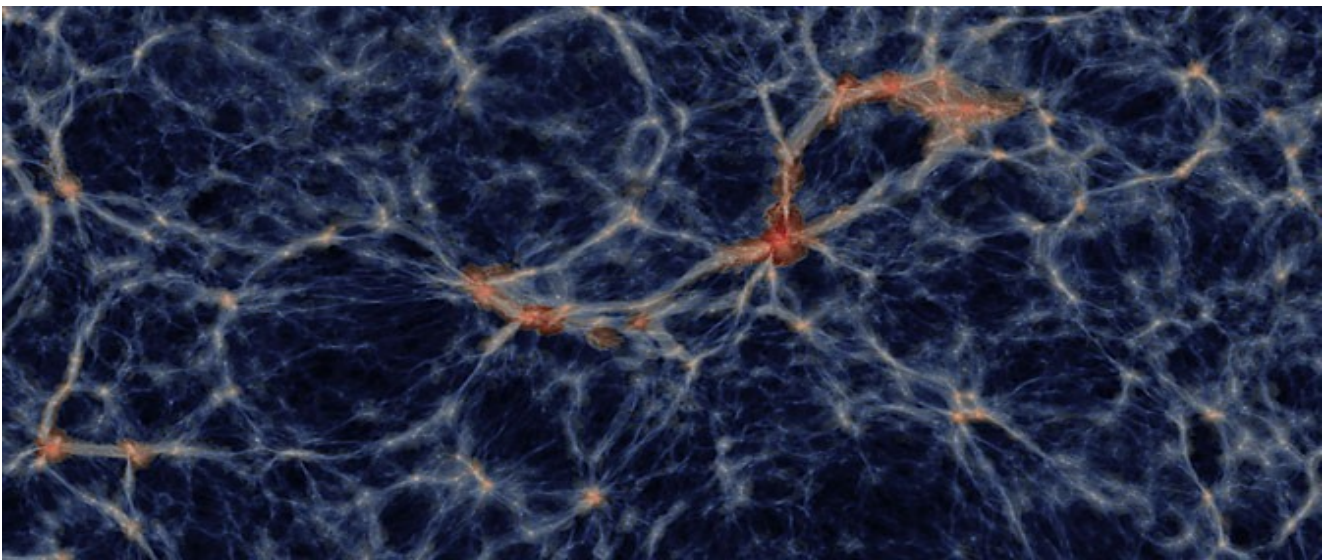


Dark Matter

The theoretical constructions and the special interesting possibilities are designed to surprise the scientists and cosmologists have just confirmed the existence of dark matter in our exclusive and beautiful universe. This mysterious dark matter is invisible however it provides the bulk of gravity that holds galaxies but not the regular matter that forms the stars and planets. This invisible dark matter has weird collision properties, where we cannot see dark matter nor collide but we can detect its gravity. In some current observations, two huge clusters of invisible dark matter clashed with each other. With each cluster having a mass of tens of thousands galaxies. In order to explain why this invisible dark matter neither collided with each other, nor did it collide with us but still we detected its gravity, physicists and cosmologists are working on theories with extra dimensions like the supersymmetry, supergravity and superstrings. The conservative view is today even more accepted by scientific community, because of discovering more, and new types of evidence. It leads to the difference between the galaxy mass predicted by the luminosity and the mass predicted by the velocities. This difference offers strong evidence that spiral galaxies are embedded in extended halos of dark matter. The most convincing observational evidence for the existence of dark matter involves galactic dynamics, there is simply not enough luminous matter observed in spiral galaxies to account for their

observed rotation curves. In astrophysics, there is overwhelming evidence that most of the mass in the universe is some non-luminous dark matter with unknown composition. There are also reasons to believe that the bulk of this dark matter is non-baryonic, that it consists of some new elementary particle. After reviewing the theoretical, phenomenological and experimental motivations for supersymmetric extensions of the standard model, we recall that supersymmetric relics from the big bang are expected in models that conserve the parity. The physicists then discuss possible supersymmetric dark matter candidates, focusing on the lightest neutralino and the gravitino. Historically, the second motivation for low-scale supersymmetry, and the one that interests us most here, was the observation that the lightest supersymmetric particle in models with conserved parity, being heavy and naturally neutral and stable, would be an excellent candidate for dark matter. Astrophysical and cosmological observations indicate that the universe undergoes an accelerated expansion, which is dominant at present time with the interactions of dark matter and dark energy. Existing besides ordinary matter, the remaining twenty three percent of matter is an unknown form that interacts in principle only gravitationally, this form of matter is known as dark matter. In the constructions are many sound theoretical and phenomenological reasons to favour supersymmetric extensions of the standard model. In particular, supersymmetry predicts the existence of cold dark matter in a very natural way, and there are several plausible candidates for the lightest supersymmetric particle that would be present as a relic from the big bang. The most prominent candidate is the lightest neutralino, and we have described how its relic density may be calculated, and the regions of supersymmetric parameter space in which its density falls within the range favoured by astrophysics and cosmology. However, other candidates for the cold dark matter are also possible, such as the gravitino. In that case, the next-to-lightest supersymmetric particle would be metastable, and comparisons between the observed light-element abundances and those predicted by the nucleosynthesis calculations impose important constraints on the parameter space. We have given examples of neutralino and gravitino dark matter scenarios

in the minimal supersymmetric extension of the standard model, under various different theoretical assumptions. From the above viewpoint, the existence of attractive dark-matter candidates in models possessing low-energy supersymmetry can be regarded as an independent and pleasant surprise. To our minds, this pleasant surprise provides an excellent motivation for studying these models. Supersymmetric dark matter remains one of the most interesting and viable candidates for cold particle dark matter. Finally, there is at least some suggestion that low-energy supersymmetry exists from coupling constant unification arguments. Supersymmetric theories of physics beyond the standard model provide perhaps the most promising candidates to solve the composite conundrums of particle physics and cosmology, providing a common paradigm for new particle physics and for cosmology. Although speculative, supersymmetric dark matter is very well motivated and based on a simple physical principle. This coincidence between new physics at the electroweak scale and a solution to the dark matter problem is highly suggestive and should not be ignored.

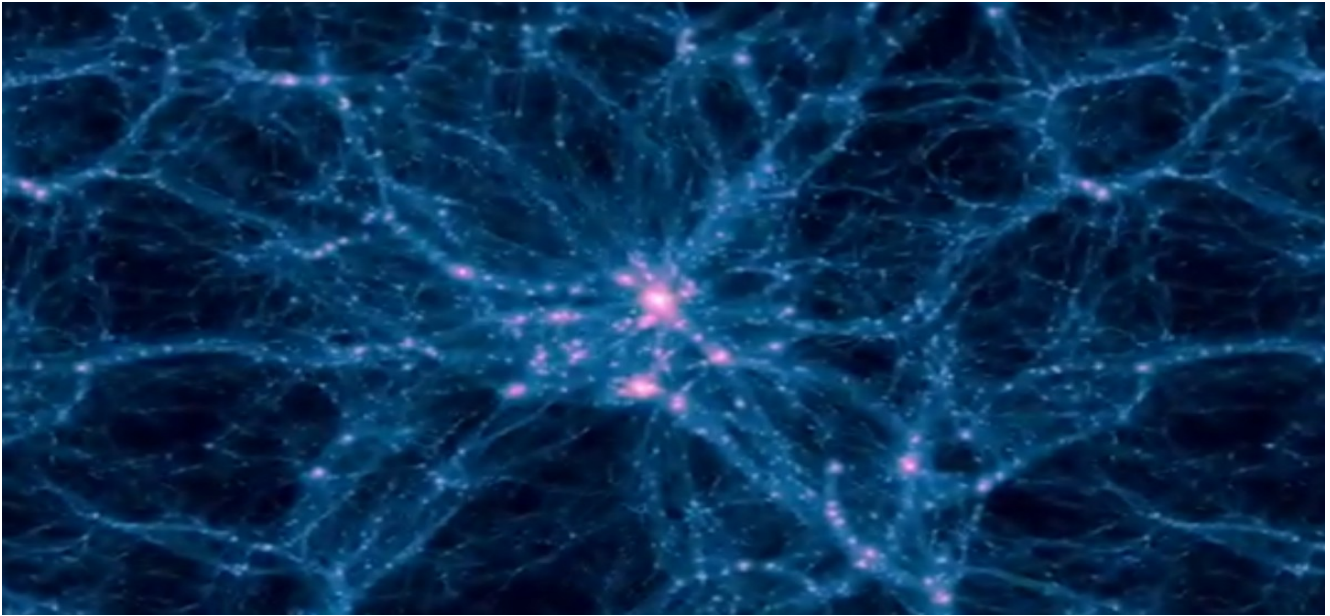


Dark Energy

Cosmological observations show evidence for an accelerated expansion, usually attributed to the new form of energy, dubbed dark energy. The simplest model for dark energy is the cosmological constant. From the point of view of particle physics, the cosmological constant is interpreted as the energy of the vacuum of the universe, which must

be, according to the current observations. The existence of a pure cosmological constant has been the most economical way of interpreting the observational data. Yet such a tiny cosmological constant is drastically at odds with particle physics and therefore calls for a deeper explanation. Of course it could well be that the acceleration of the expansion of the universe is not due to dark energy but to a large scale modification of gravity. This possibility is under intense scrutiny plus on the other hand, if correct, the observation of a tiny vacuum energy is all the more puzzling as the physics of phenomena at a such a low energy scale is well known and has been tested in the high-energy laboratory experiments. The current understanding is that dark energy, or equivalently a positive cosmological constant, is accelerating the expansion of the universe and the researchers show that this gives higher-dimensional spacetime positive curvature. The potential way for detecting dark energy and distinguishing it from the pure vacuum energy is through its equation of state. Their equation of state depends on the evolution of the expansion rate and is a complicated tracking solution because they contribute to the expansion rate and their equations of motion are coupled to the the general equation for expansion. Seventy three percent of our universe consists of the still mysterious component of dark energy, which is believed to be responsible for the present acceleration of the universe. Among a wide range of alternatives for the dark energy, which includes the cosmological constant, scalar or vector fields, modifications of gravity and different kinds of cosmological fluids, the usage of a canonical scalar field, called quintessence, is the viable and natural candidate. Another striking attempt to explain the acceleration comes from holography. The holographic principle states that the degrees of freedom of a physical system scales with its boundary area rather than its volume. The current researchers and collaborators suggested that the dark energy should obey this principle, thus its energy density has an upper limit and the fine-tuning problem for the cosmological constant is eliminated. From the point of view of theoretical physics, it would be interesting find out a model of dark energy from first principles, since supergravity is the low-energy limit of the superstring theory, it

is natural to investigate if it can provide a model that describes the accelerated expansion of the universe. The simplest supergravity case is with one supersymmetry and in the theoretical framework presented some models that try to describe dark energy through quintessence. Due to the prominent role of the superstrings correspondence to relate both supergravity and holography concepts, it is natural to ask if there is any connection between supergravity and the holographic dark energy. Interesting supergravity equation was deduced for a dark-energy-dominated universe, in such a way that the interaction with dark matter is absent, as it should be in this limit, where we embedded two models of holographic dark energy in the minimal supergravity with one single chiral superfield in the supergravity multiplet. Dark energy is one of the most intriguing puzzles of present day physics which presents some of the peaks of the current state of knowledge about our world and the fundamental nature. When interpreted within the realm of general relativity, its existence is linked to the presence of a weakly interacting fluid with a negative equation of state and a dominant energy density. The simplest possibility is of course a pure cosmological constant plus the plausible alternative involves the presence of a scalar field responsible for the tiny vacuum energy scale. This suggests to embed such models in the theoretical high energy physics. The most natural possibility is supergravity as it involves both supersymmetry and gravitational effects, moreover, superstring theories lead to supergravity models at low energy. From the model building point of view, the quintessence field does not belong to the standard model. Hence there must be a separate dark energy sector. The observable sector is well-known and the hidden supersymmetry breaking sector can be parameterised. As soon as a quintessence field has a runaway potential and leads to the present day acceleration of the universe expansion, its mass is tiny and may lead to gravitational problems. In order to minimise this problem, we assume that the quintessence sector is only coupled gravitationally to the observable and hidden sectors. The nature of the dark sector is still mysterious and it is one of the biggest challenges in the modern cosmology with which the near future will determine the profound results of research in the depths of the dark universe.



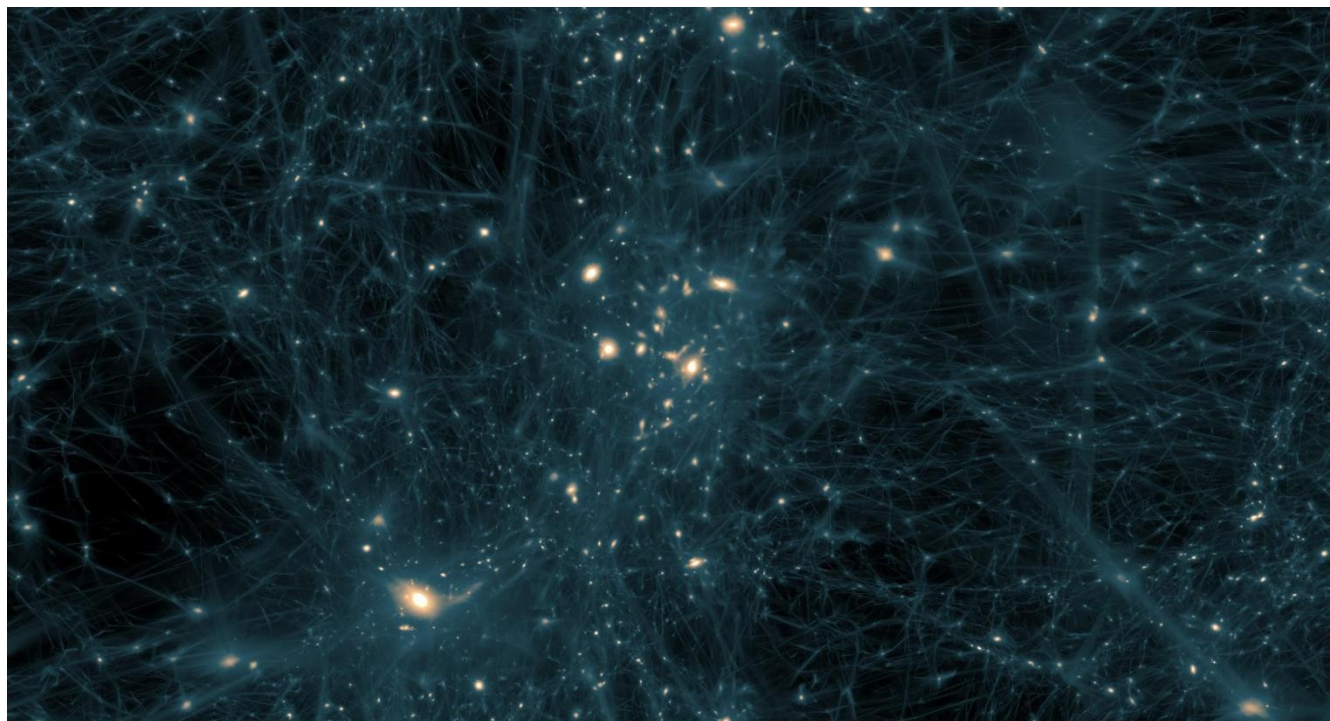
The Dark Matter and Dark Energy in Supergravity Models

The scientists examine the embedding of dark matter and dark energy in high energy models based upon supergravity and extend the usual phenomenological setting comprising an observable sector and a hidden supersymmetry breaking sector by including a third sector leading to the acceleration of the expansion of the universe. The interaction between the hidden and dark sectors implies that all the soft breaking terms acquire a supergravity dependent form and this has a drastic effect on the gravitational physics at low energy scales. We assumed that the dark energy hidden sector can be successfully incorporated into the theory of elementary particles and that the cosmological constant problem in the observable sector can somehow be solved. But this is the general issue with all models of dark energy. On the other hand, the new class of models may provide an unusual solution to the coincidence problem. Supergravity can provide a natural candidate for dark matter, which in the case is the gravitino. Once local supersymmetry is broken, the gravitino acquires a mass by absorbing the goldstino, but its mass is severely constrained when considering standard cosmology. The gravitino may be the lightest superparticle being either stable, and in another possibility is the gravitino to be the next-to-lightest superparticle, so that it decays into standard model particles or into lightest superparticle. From the cosmological point of view, if the gravitino is stable should be very massive particle in order

not to overclose the universe. Thus the gravitino may be considered as dark matter, however such value is not what is expected to solve the hierarchy problem and the gravitino describes only hot and warm dark matter, then another candidate is needed. If the gravitino is unstable it should have big mass to decay before the big bang nucleosynthesis and therefore not to conflict its results. There are two sectors, the observable sector and the hidden sector plus the assumption that the two sectors interact only gravitationally with the supersymmetric representations of quantum gravity in diverse dimensions. Then, the main issue is to understand how dark energy can be implemented into the above framework. Dark energy cannot belong to the observable sector as this would lead to a strong fifth force signal unless the coupling constants are artificially tuned to be small. We discard this possibility. Dark matter and dark energy could belong to the same sector. Couplings between dark matter and dark energy have been studied in the past with interesting results. However, in the minimal supersymmetric standard model, dark matter belongs to the observable sector, as a result, dark matter and dark energy will have only gravitational interactions. Finally, dark energy could belong to the supersymmetry breaking sector and the researchers assume that dark energy and the breaking of supersymmetry occur in separate sectors. This is motivated by the fact that supersymmetry breaking happens at a very large scale compared to the dark energy scale. At high energy, the hidden sector field, still assumed to be stabilised, picks up the vacuum values which are perturbed by the gauge coupling to the dark energy sector. Within the realm of the theoretical high energy physics, this has prompted the use of supergravity where large field values can be handled. In supergravity models of particle physics, two sectors are envisaged generically. The so-called hidden sector breaks supersymmetry leading to a splitting of masses between the super-partners in the observable sector. In this setting the observable sector can be taken to be the minimal supersymmetric standard model and minimal supergravity whose phenomenology has been thoroughly studied and may be discovered at the present time most powerful and high energy machine the Large Hadron Collider in CERN. Moreover supergravity models may play the role of low energy theory for a

putative unified theory like superstring theory. Dark energy must be included in this setting and is required to belong to a separate sector. This is to prevent the direct couplings between dark energy and baryons, which would lead to large deviations in tests of gravity and the large discrepancy between the supersymmetry breaking scale and the vacuum energy scale. We find that gravitational constraints on the non-existence of a fifth force naturally imply that the dark energy sector must possess an approximate shift symmetry. When exact, the shift symmetry provides an example of a dark energy sector with a runaway potential and a nearly mass less dark energy field whose coupling to matter is very weak, contrary to the usual lore that dark energy fields must couple strongly to matter and lead to gravitational inconsistencies. In this respect, extended supergravity may be particularly interesting as the dark energy hidden sector if the mysterious mass quantization rule has some fundamental meaning and remains stable with respect to the interaction of the ultra-light scalars with the fields from the observable sector. One may even argue that the reason for using extended supergravities is due to the nature of gravitational and vector fields that may live in five dimensions or higher, where the supersymmetry generators is the smallest supersymmetry available. However, realistic models of supersymmetry breaking in the context of supergravity, membranes and extra dimensions are yet to be developed. For the time being, one may consider the simple models of dark energy based on supergravity as the special theoretical models with some interesting and very unusual features that could be studied by cosmological observations. Now let us see whether this cosmological picture can be related to supergravity higher-dimensional interactions of the dark energy. The generic higher-dimensional gauged supergravity which will be used for dark energy hidden sector has part which includes supergravity coupled to scalar superfields and the current superpotential. We assume that there is a dark energy interaction given by extended supergravity with the solution and that in addition to the scalars representing the dark energy of the universe there is also the usual cold dark matter energy density contribution of the cosmological equations. The dark matter density is given by a ratio of the dark

energy to the total energy. Our particular interest in the cosmological aspects of the theory with maximal supersymmetry is the common trend to have maximal amount of supersymmetry allowed by experimental and theoretical considerations. M-theory supergravity or supergravities related to low energy superstring theory, compactified on superspaces may lead to non-trivial superpotentials. Since all critical points linked to M-theory are unstable and the potentials are unbounded from below, one could expect that these models cannot describe the past and current evolution of the universe and play the role of the dark energy hidden sector. It is therefore interesting to study in this model of axion-dilaton dark energy the evolution of the universe during the last cosmological time and the future evolution towards the supergravity sector and see what kind of features of dark energy and accelerated universe may be described by this model.

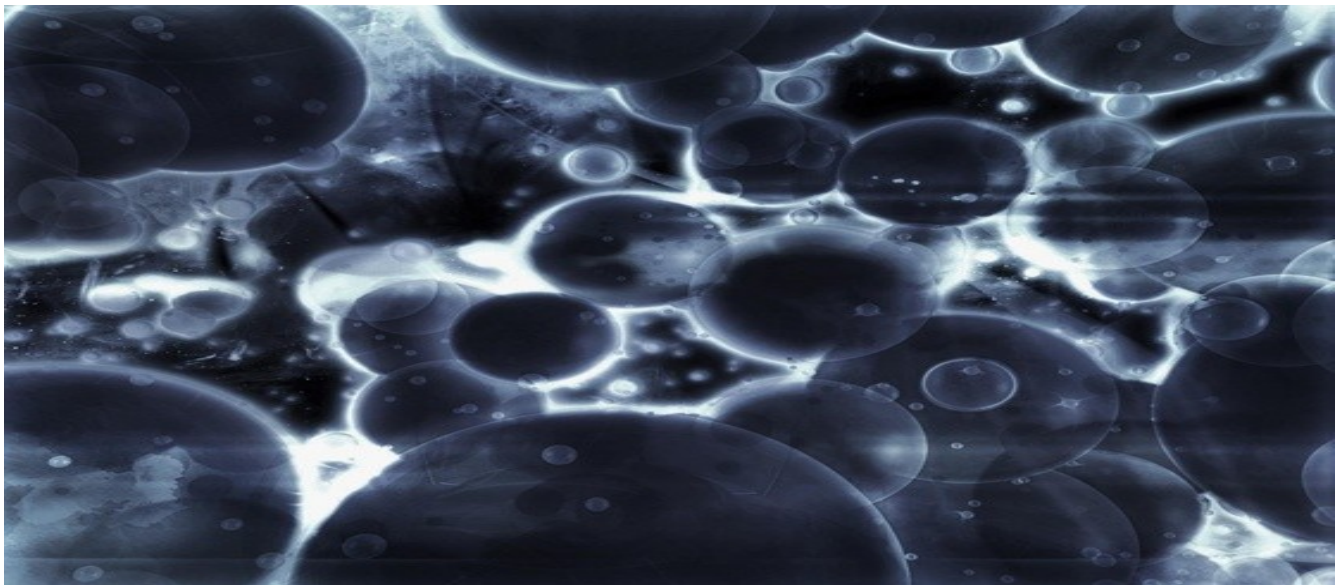


The Dark Matter and Dark Energy in Superstring Models

The mysterious cosmic presence called dark energy, which is accelerating the expansion of the universe, might be lurking in hidden dimensions of the higher-dimensional superspace. The idea would explain how these dimensions remain stable and continuous, which is one big problem for the unified scheme of modern theoretical physics

called superstring theory. In ordinary superstring theory, with no spacetime boundaries in the low-energy spacetime, such ambiguities imply that the ghost combination where the superstring coupling and the dilaton field, can always be achieved for the quadratic curvature terms in the superstring inspired low-energy effective action, which constitutes the first non trivial order corrections to the gravitational term in the bosonic and heterotic superstring effective interactions. This behaviour can be studied in a generic perturbative superstring theory, based on the form of low energy potentials of possible quintessence candidates. Because realistic superstring theories involve at a certain stage supersymmetry in target superspace, which is broken as we go down to the four dimensional world after compactification, or as we lower the energy from the superstring scale, such arguments depend on the form of the potential, dictated by supersymmetry breaking considerations. The situation is opposite that of the standart construction, where as we have seen the superstring coupling becomes weaker with the cosmic time, and perturbative superstrings are sufficient for a description of the Universe at late epochs. The starting point is the higher-dimensional superstring frame, the low-energy superstring inspired effective action with graviton and dilaton backgrounds, to lowest order in the expansion, but including dilaton-dependent loop and non-perturbative corrections, which are essential given that at late epochs the dilaton grows strong in the different scenaria. All such cosmologies require some physical reason for the initial departure from the conformal invariance of the underlying model that describes superstring excitations in such types universes. The observed small value in natural units has an explanation in the cosmology of closed superstrings and thus the dark energy provides an exciting opportunity to connect superstring theory to precision cosmology. We may argue that numerically the size of the cosmological constant in the present approach is a combination of the superstring scale and the expansion rate in the sense of the present theory. One of the most important issues concerns the superspace, and in general the spacetimes with horizons in superstring theory are the general properties, including holographic scenaria, which may be the key to an inclusion of such spacetimes in the set of consistent

ground states of superstrings. The problem of dark energy arises due to its self-gravitating properties. Therefore explaining vacuum energy may become a question for the realm of quantum gravity and supergravity, that can be addressed within superstring theory context. In the article we concentrate on a recent, superstring-inspired model, that relies on nonlinear physics of short-distance perturbation modes, for explaining dark energy without any fine-tuning. Dark energy can be observationally probed by its equation of state. Different models predict different types of equations of state and superstring-inspired ones have a time dependent as their unique fundamental signature. Exploring the link between dark energy and superstring theory may provide indirect evidence for the latter, by means of precision theoretical, cosmological and experimental data. The transition from superstring theory to conventional cosmology is becoming increasingly important to theoretical physics. The quantum corrections to short distance physics due to the nonlocal nature of superstrings contribute to dark energy. The possibility to detect their signature observationally of the dark energy is thus very intriguing and inspiring task.



The Dark Matter and Dark Energy in Membrane Models

In some membrane world models, dark energy is the result of gravitational tension between our universe and the local neighboring membrane. One version in the cyclic model predicts that dark energy

will dissipate at some point in the future as the membranes reach a critical distance from each other, after which point cosmic expansion will reverse. While that point is far in our future, we may be able to spot other signatures of the higher-dimensional reality constructed with fundamental membranes, where the big bang in the cyclic model marks the moment when our universe collided with the neighboring membrane. Another style of modification to gravity is more subtle and elegant in the construction. These theories extend the known rules into a higher-dimensional reality, the membrane world models depict the universe we know as a surface or membrane, with one or more extra dimensions that we can't access directly. However, gravity reaches into the extra dimensions, and other membranes could influence what goes on in our observable cosmos. We need to move from a particle-based view of our universe to a membrane and superstring based view. Researchers are having trouble figuring out dark matter, dark energy, and many other recent discoveries because they view our universe as a collection of particles within a vacuum with nothing beyond the edge of our universe. Even M-Theory currently suffers from this view as it still does not see our membrane as the source of gravity, with each string currently behaving like a particle in standard physics. This new version of the big splash with membrane gravity does away with all the breakdowns of physics, infinite energies, and infinitely small sizes of the old big bang model. This leaves a much more stable and robust theory for the creation of our universe. It also predicts dark matter, dark energy and how they change over time which neither the standard model or M-Theory constructions. The small percentage of energy that got through to the virtual strings within each membrane vibrated the higher-dimensional supergravity interactions of each superstring. This directly transferred energy to the non-energetic virtual superstrings within each membrane, creating matter and antimatter quarks and electrons in up and down pairs. The major membrane vibrations that act as dark matter vibrate over large areas thousands of light-years across and even form dark matter galaxies. Huge chains of galaxy clusters are created, attracted to these long strands of dark matter, and form an enormous lattice of strands following the membrane vibrations and appearing similar to a

three-dimensional spider's web. Membrane supergravity would help to explain these huge structures as well, because as our membrane was compressed during the collision due to its vibrations, a network of crossing membrane waves would form. These vibrations of the membrane itself would cause it to contract quickly into a much smaller volume as the membrane vibrates rapidly back and forth. It would form huge waves, both on the outer surface and throughout the inner structure of the higher-dimensional membrane. The dark matter resulting from membrane vibrations could also cause the gases of the early universe to collapse and form into stars and galaxies earlier than one billion years after the big splash, much more rapidly than current theories including the standard model and M-Theory can explain satisfactorily. In addition, because our membrane was contracting at the same time our universe was being formed, our universe was created at speeds effectively faster than light. As our universe is currently expanding faster than light due to the expansion of our model, the universe is a region on a multidimensional fundamental membrane, and this higher-dimensional membrane is only one of many. When these membranes collide huge regions of our membrane get bunched into extremely uninhabitable black holes, with only a small region of space left for us, without dark energy to inflate these gaps, a few cycles of this would annihilate everything. The membrane of our universe expands, the same process happened in reverse when our membrane collided with another swimming and interacting parallel membrane. As our universe appears to expand close to its original size before the collision, our galaxies will begin to fly apart as their dark matter halos begin to relax their dark matter membrane vibrations. Eventually, the stars themselves will begin to get dimmer signals as the dark matter in our galaxy dissipates where the fundamental matter interact in the membrane. In the modern approach to superstring theory, where the membrane structures also appear as mathematically consistent entities, the presence of a dark energy on the superstring theory on the membrane is unavoidable, unless extreme conditions on unbroken supersymmetry and static nature of membrane worlds are imposed. However, in membrane cosmology one needs moving membranes, in order to obtain a

cosmological spacetime, and in this case the target spacetime supersymmetry breaks down, due to the membrane motion, resulting in non-trivial vacuum energy contributions on the membrane. Another example arises in a non-critical superstring approach to inflation, if the big bang is identified with the collision of two membranes in the hyperspace. In such a scenario, astrophysical observations may place important bounds on the recoil velocity of the membrane worlds after the collision, and lead to an estimate of the separation of the membranes at the end of the inflationary period. The vibrations of our membrane are not contained within a small, confined superspace as the vibrations of regular superstrings are spread in the higher-dimensional curved spacetime. Superstrings vibrating within our universe that act as matter plus energy and are confined to the fundamental length. Because the membrane vibrations have our entire membrane to expand and vibrate throughout, the vibrations will dissipate throughout our entire membrane. They radiate according to the inverse square law as the waves expand in higher-dimensions and dissipate throughout our universe into the rest of our membrane. As our universe expands, the dark matter membrane vibrations will slowly be converted into dark energy as those vibrations relax and dissipate, pushing points that were close together farther apart. This will happen as the vibrations of our membrane occur less frequently, especially in the empty regions of the universe between galaxy cluster strands. However, in the case of membrane worlds, with closed superstrings propagating in the bulk, things are not so simple. As discussed in the present literature, field redefinition ambiguities for the bulk low-energy gravitino and dilatino superfields, that would otherwise leave bulk superstring scattering amplitudes invariant, induce membrane boundary curvature and cosmological constant terms, with the unavoidable result of ambiguities in the terms defining the cosmological constant terms on the membrane. This results in ambiguities in the cross-over scale of higher-dimensional membrane supergravity, as well as the membrane vacuum energy. It is not clear to the researchers, however, whether these ambiguities are actually present in low-energy membrane world scenarios. The scientists believe that these bulk-superstring ambiguities can be eliminated once the

membrane effective theory is properly defined, given that closed and open superstrings also propagate on the membrane world hypersurfaces, where thus are characterised by their own scattering amplitudes and in the specific way they interact in the higher-dimensional curved spacetime. Almost the entire amount of the gravitational interactions in the cosmos are caused by the dark matter and dark energy. The ether wind acts on the slope of the membrane in the gravitational funnel and causes a thickening of the membrane. We find two additional members in the differential equations of the spacetime curvature associated with dark matter and dark energy. Simulation experiments with models of galaxies gave dark matter coefficients of great rate of darkness in the universe. We have studied the coupling of dark energy to the standard model assuming that the three sectors, which are the dark energy, supersymmetry breaking and the minimal supersymmetric standard model are decoupled and only interact gravitationally with the special interactions of supergravity. This implies that the standard model couplings become functions of the dark energy field measured in the fundamental units, where if the gravitational interactions are turned off, no coupling between the sectors would exist. These results are intrinsically dependent on the initial ansatz for the different superpotentials in the theory. Introducing direct couplings between the dark energy sectors and the other two sectors would increase the gravitational effects unless the couplings were chosen to exactly cancel the gravitationally induced interactions. Now we take lessons learned in extended supergravities and use them as a guide for the models which may give us a successful description of the recent past of our universe, including the acceleration period, and lead to particular prediction about the future. That is why we would like to look for simpler models based on higher-dimensional supergravity theories that may also describe dark energy and to be built and completed studied the various possibilities to describe dark energy in supergravities and the future of the universe in such models. Construction of the grid and boundary conditions in the case of our membrane universe, where the case is based on some membrane theories of gravity and supergravity, where is found in the theory the

special scientific relevance. The membrane in the higher-dimensional hyperspace which is the bulk space is stretched, we can imagine as a tensioned elastic membrane, where the surface of the fundamental membrane is created and universally fixed. In this popular article we have chosen a different strategy, where considered several theoretical models based on extended supergravity which may have closer relation to the M-theory. All of these models share a very interesting feature, where the absolute value of the effective mass squared of the scalar field responsible for the dark energy of the universe in these models is of the same order as the effective potential of this supergravity field. Whereas in phenomenological models of quintessence this property usually is required for their consistency, in supergravity this feature is rather common and sometimes it is even unavoidable. The eternal inflation, dark energy, superstrings and M-theory converge to the existence of a multiverse where all the universes would be different in appearance but with properties unimaginable. Some have neither light nor matter, but because the possibilities are endless, obviously there should be one that could look like our, this do to say the followers of science fiction there is a copy of our universe who lives in a higher-dimensional cosmic membrane. While we have not seen these membranes all delirium, superficial and frenzied interpretations are possible in the theoretical constructions. The cooling of our universe will start to convert the potential energy of our vibrating membrane dark matter into the kinetic energy of dark energy. This release of potential stored vibrating energy pushes our universe apart, accelerating slowly at first, and then increasing in speed until it relaxes nearly to its original size before the splash at which point the acceleration decreases and eventually will end. During the early universe, the large number of massive gravitational waves produced from orbiting black holes, supernovae, hypernovae, and other gravity wave sources may have aided in sustaining our membrane's rapid vibrations, preventing our universe from accelerating faster in the beginning. The closed-loop graviton superstring is what is holding M-Theory back from becoming a complete theory of physics. The picture of our universe becomes so much clearer when we realize that we live within a fluid-like membrane that is the source of our

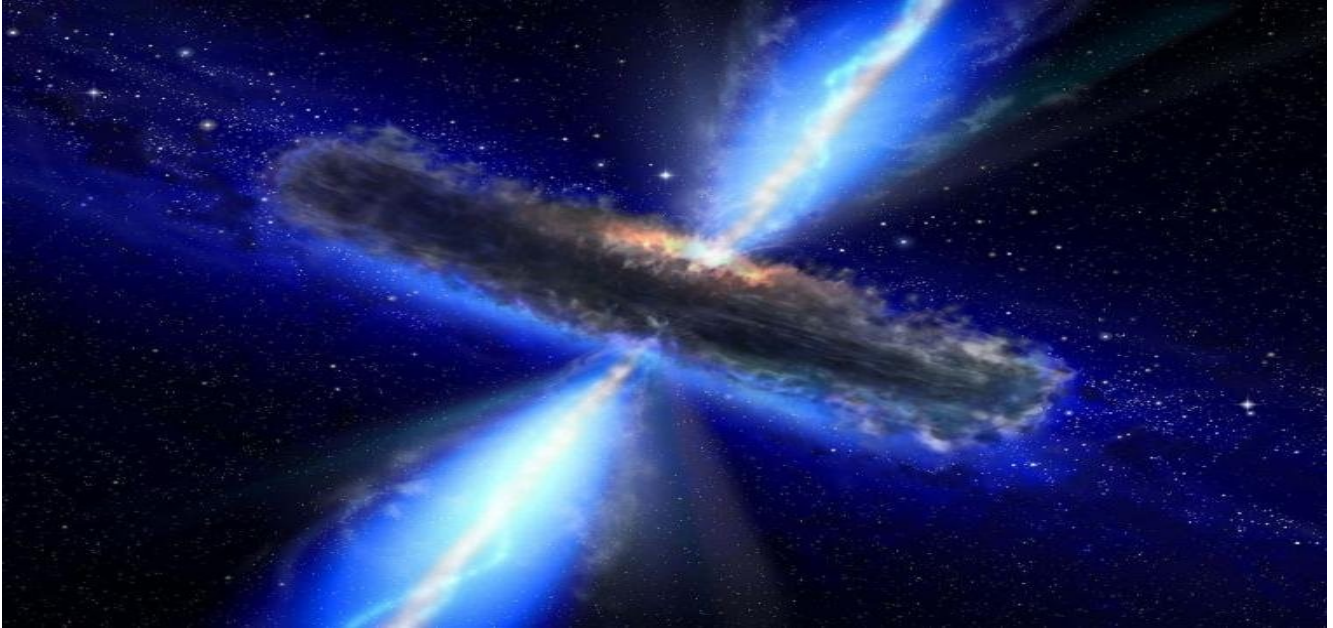
gravitational force. Because of this, all matter and energy are simply vibrating strings, formed from and connected to our membrane, that travel through our membrane and whose vibrations generate all the forces of nature that we observe. In this model, the universe is a region on a multidimensional fundamental membrane, and this higher-dimensional membrane is only one of many. When these membranes collide huge regions of our membrane get bunched into extremely uninhabitable black holes, with only a small region of space left for us, without dark energy to inflate these gaps, a few cycles of this would annihilate everything. This makes all models with the higher-dimensional curvatures and fundamental membranes interesting candidates for the role of the dark energy.

The Supersymmetric Black Holes in Supergravity, Superstrings and Fundamental Membranes

The research presented in this popular article mostly deals with black holes in context with the theoretical framework of supergravity, superstring theory and membrane theory, as a quantum gravity descriptions of the special type supersymmetric black holes. The physics of black holes, with its theoretical and phenomenological implications, has a fertile impact on many branches of natural science, such as astrophysics, cosmology, particle physics and, more recently, mathematical physics and quantum information theory. This is not so astonishing in view of the fact that, owing to the singularity theorems, the existence of black holes seems to be an unavoidable consequence of general relativity and of its modern generalizations such as supergravity, superstrings and M-theory. A fascinating aspect of black-hole physics is in their supersymmetric properties that seem to encode fundamental insights of a so far not established final theory of quantum gravity. It is conceptually straightforward to find complicated charged black hole solutions of interest, such as the most general black hole of supergravity, given the existence of well-known algorithms and suitable uncharged black hole solutions, but it can be a difficult theoretical task. The supersymmetric black holes are some

of the most important objects in the diverse dimensions of supergravity, superstrings and supermembranes. To understand their fundamental properties, such as their microscopic description, it is essential to have explicit black hole solutions and understand all their quantum properties. The approach we take to study scalar flows in supersymmetric black hole backgrounds, always starts from a higher-dimensional interaction that encompasses the supergravity scalar dynamics. In the literature, one typically writes down two different fundamental interactions for the dependent fields coupled to the supersymmetric black hole in higher-dimensional curved background. The recent equations of motion corresponding to the effective action with a black hole potential, describing static, spherically symmetric black hole solutions in infinite dimensions, fit in the established theoretical description. Black hole solutions to extensions of general relativity, such as the various kinds of supergravity naturally occurring in the low-energy effective description of superstrings, often exhibit features unknown from the pure and standard gravitational theory. We use such a simplifying principle to shed light on the structure of black hole and membrane solutions, but also to see if we can learn more about time-dependent solutions of supergravity and superstring theory, since especially these latter ones are hard understood in the context of superstrings and membrane theory. The analysis just described is readily generalized to extreme, dilaton black holes, or extended objects, in a infinite dimensional spacetime. One again finds that in certain cases, the singularity in these supersymmetric solutions can be removed via interpretation as a higher-dimensional object in a higher-dimensional spacetime. However, in this case the singularity inside the supersymmetric black hole horizon is not resolved by lifting to higher dimensions. Although there has been progress in establishing a correspondence between superstring states and certain types of black hole solutions, in general the lack of black hole uniqueness in higher dimensions makes the construction of the black hole superstring state correspondence rather more complicated. It has, however, been possible to construct a uniqueness theorem for supersymmetric black hole solutions of the higher-dimensional supergravity and related

membrane models constructed in the theoretical framework.



Supersymmetric Black Holes

The theoretical framework form a natural way to try to probe the possible simultaneous description of gravity and quantum physics, with elegant interference in the inclusion of higher-dimensional models of supergravity, superstring and membrane models. The scientists considered quantum field theory and the related supersymmetric extensions in the fixed gravitational background of the black holes. We will be concerned with specific supersymmetric theories which exist in diverse dimensions, along with their black hole solutions in the higher-dimensional curved spacetime. The supersymmetric black hole is invariant under some of the supersymmetry transformations that relate the interactions of bosons and fermions in superspace. Over the last two decades, many developments of superstring theory have been triggered by supersymmetric solutions in supergravities. In particular, supersymmetric black holes played a key role for the first successful account for the microscopic origin of the entropy. Recently a systematic classification of supersymmetric solutions has been developed and proved useful for obtaining supersymmetric black objects with various topologies. Many particularly useful and unique applications of the higher-dimensional classifications in theoretical picture constructed for the black hole physics were elegantly served

from the supergravity interpretations. If, in a given supergravity theory, the state corresponds to a background described by a certain configuration of fields is translated into the request that the supersymmetry variations of all the fields are zero in the supergravity background. We consider supersymmetric black-hole solutions for which the supersymmetry variations of the bosonic fields are identically zero. Then the conditions yields a set of equations for the bosonic fields, to be satisfied on the given configuration where the supersymmetry transformations are made with respect to the residual supersymmetry parameter defined by the supergravity constructions. We evaluate the resulting higher-dimensional interaction to obtain an exact answer for the quantum entropy of the black hole under consideration. We compare the result obtained for this macroscopic entropy against the microscopic predictions of superstring theory for the same black hole. If the last step is conclusive, so that there is an agreement between the macroscopic and microscopic descriptions of the black hole, it provides a non-trivial test that supergravity is indeed an appropriate low-energy description of superstring theory and sheds light on the statistical interpretation of the black hole's thermodynamical entropy, including all possible quantum corrections to the area-law of the black hole. The classification of supersymmetric solutions of higher-dimensional ungauged supergravity coupled to arbitrary many abelian vector multiplets is used to prove a uniqueness theorem for asymptotically flat supersymmetric black holes with regular horizons. The purpose of the researchers is to extend this uniqueness theorem to include supersymmetric black hole solutions of the ungauged supergravity theory coupled to arbitrary many vector supermultiplets. Since for the multiplet, supergravity itself is gauged, one should be able to construct a single charge encoding all gauge supersymmetries, and use this charge for a computation of the different interactions. The entropy of supersymmetric black holes has been explained by counting states in a dual regime of superstring theory, where gravity is negligible. However, this does not shed light on the nature of the microstates in the regime where we have an interpretation as a supersymmetric black hole, since this requires that the gravitational

interaction cannot be neglected in the case. This extension is useful because, although the minimal theory has many interesting properties, it corresponds to a rather restricted class of higher dimensional solutions. In order to investigate the higher dimensional physics more fully by compactification to lower dimensions, one must typically couple the lower dimensional theory to additional matter. We have learned about many aspects of the modular behavior of the microscopic functions in the generic setting of supersymmetric theories based on the modular nature of the effective superstrings when supersymmetric black holes descend from wrapped superstrings, and from the spacetime duality symmetries of the underlying theory. Without the powerful handle given by the modular symmetry, it looks at first sight like the program followed to interpret the microscopic degeneracies in supersymmetry and supergravity. In the present case, subtleties due to wall-crossing phenomena lead to the fact that the black hole degeneracies are connected to the supersymmetry, supergravity and superstrings. Lastly, when examining the more general case of the quantum states with supersymmetric black holes in higher-dimensional superstring theory and supergravity, a number of questions remain open for the next stage of research.



Extremal Black Holes in Supergravity

The extremal black hole configurations are embedded in a natural way in supergravity theories in diverse dimensions. Indeed supergravity, being invariant under local super transformations, includes general

relativity, where it describes gravitation coupled to other fields in a supersymmetric framework. Therefore it admits black holes among its classical solutions. Moreover, as black holes describe a physical regime where the gravitational field is very strong, a complete understanding of their physics seems to require a theory of quantum gravity. In this respect, as anticipated above, extremal black holes have become objects of the utmost relevance in the context of superstrings. This interest, which is just part of a more general interest in the membrane classical solutions of supergravity theories in all dimensions, stems from the interpretation of the classical solutions of supergravity that preserve a fraction of the original supersymmetries as non-perturbative states, necessary to complete the perturbative string spectrum and make it invariant under the many conjectured duality symmetries. Extremal black holes and their parent membranes in higher dimensions are then viewed as additional particle-like states that compose the spectrum of a fundamental quantum theory. As the monopoles in gauge theories, these non-perturbative quantum states originate from regular solutions of the classical field equations, the same equations one deals with in classical general relativity and astrophysics. The essential new ingredient, in this respect, is supersymmetry, which requires the presence of vector and scalar fields in appropriate proportions. Within the superstring framework, supergravity provides an effective description that holds at lowest order in the superstring expansion and in the limit in which the spacetime curvature is much smaller than the typical superstring scale. The supergravity description of extremal black holes is therefore reliable when the radius of the horizon is much larger than the superstring scale, and this corresponds to the limit of large charges. Superstring corrections induce higher derivative terms in the low energy action and therefore the black hole entropy formula is expected to be corrected as well by terms which are subleading in the small curvature limit. In this paper we will not consider these higher derivative effects. Thinking of a black-hole configuration as a particular bosonic background of an extended locally supersymmetric theory gives a simple and natural understanding of the cosmic censorship conjecture. Indeed, in theories

with extended supersymmetry the bound is just a consequence of the supersymmetry algebra, and this ensures that in these theories the cosmic censorship conjecture is always verified, that is there are no naked singularities. When the black hole is embedded in extended supergravity, the model depends in general also on scalar fields. Translating the supersymmetric equations into an explicit differential system requires knowledge of the supersymmetry transformation rules of supergravity. The saturation condition transfers the geometric structure of supergravity, associated with its scalar sector, into the physics of extremal black holes. For the black holes, the fixed point is reached precisely at the black-hole horizon, and this is how in the special case of internal behavior is realized for this class of extremal black holes.



Heterotic Black Holes in Superstring Theory

The universal and unique higher-dimensional black hole solutions in heterotic superstring theory, which contain mass and electric charge, are obtained from the effective interactions of heterotic superstrings. Theoretical physicists construct the general electrically charged, rotating black hole solution in the heterotic superstring theory compactified in the diverse dimensions and study its quantum properties based on the heterotic constructions. They investigate the possibility that the duality symmetry is an exact

symmetry of superstring theory under which the electrically charged elementary superstring excitations get exchanged with magnetically charged solutions in the theory of heterotic black holes. We use the black hole entropy function to study the effect of terms on the entropy of extremal black holes in heterotic superstring theory in higher dimensions. We find that after adding a set of higher curvature terms to the effective interaction, the mechanism works with terms contribute to the stretching of near horizon geometry. In the landscape limit, the solutions of superstring equations for moduli fields and the resulting entropy, are in conformity with the ones for standard two charged heterotic black holes. Recent publication studied the size and shape of the shadow cast by a charged rotating black hole from the low-energy effective field theory describing heterotic string theory, which have properties which are qualitatively different from those that appear in the general theory of gravity. The size and shape of the shadow, depending on the mass, electric charge and angular momentum of the heterotic black hole and the results realized and presented in current developments are calculated and deeply analyzed. Recently, a possible method to constrains such parameters has emerged in the theoretical framework with the observation of black hole shadows. The shadow of a black hole corresponds to the lensed image of the event horizon and participates in the higher-dimensional dark zone. Evidence suggest that there is a large number of black holes in heterotic and eleven-dimensional theories, where some of them may have exotic topologies. The horizons sections have special geometry and their existence is closely related the existence on solutions to the equations of supermanifolds. Assuming that the supermassive black hole can be described by the heterotic black hole metric, the astronomical observables and angular radius of the shadow are obtained. In the case on particular class of extremal four-dimensional black-holes occuring in compactified heterotic superstring theory was connected to the class of extremal higher-dimensional heterotic black-holes presented in the current literature. The higher-dimensional heterotic black-hole solutions under consideration are thus related by duality to four-dimensional heterotic black-hole solutions. In addition to considering these solutions in the

framework of higher-dimensional supergravity one may address the issue of stringy quantum corrections for the heterotic black holes. The stringy quantum corrections related to the gravitational anomaly in the general context on unbroken supersymmetry of the heterotic superstring have been analyzed in deep details. Analysis on the heterotic black hole solution of the low energy effective field theory given by the supergravity interactions realizes zero area of the event horizon. The researchers consider a class of extremal and non-extremal four-dimensional black-hole solutions occurring in compactified heterotic superstring theory, whose ten-dimensional interpretation involves the type of higher-dimensional membrane. They show that these four-dimensional solutions can be connected to extremal and non-extremal two-dimensional heterotic black-hole solutions through a change in the asymptotic behaviour of the harmonic functions associated with the membrane. Finally we note that for heterotic superstring theory compactified or more general supersymmetric string compactification, the statistical entropy of some of the heterotic black holes can be computed exactly by representing them as configuration of the membranes.



Dyonic Black Holes in Supergravity and Superstring Theory

The dyonic black hole solutions can be embedded into maximal gauged supergravity and superstring models in the higher dimensions.

However, we consider a rather interesting solutions, which solves the equations of motion obtained varying the interactions in diverse dimensions in presence of a cosmological term. It is shown that the hidden conformal supersymmetry, namely symmetry of the dyonic black hole can be probed by a charged massless scalar superfield at low frequencies. The existence of such hidden conformal supersymmetry suggests that the field theory holographically dual to the black hole indeed should be the conformal supergravity. We show that the hidden conformal supersymmetry can be found also for the dyonic black hole, which indicates that the generic non-extremal dyonic black hole is dual to the conformal supergravity. However, from the technique of probing the hidden conformal supersymmetry of dyonic black hole backgrounds via external fields, we suggest that even for the generic non-extremal dyonic black hole, it should still dual to the conformal supergravity once we correctly incorporate the contribution of the background gauge field. In practice, the supersymmetry of the background electromagnetic field can be probed by an external charged scalar field, consequently, the hidden conformal supersymmetry of the dyonic black hole is revealed. An exact solution of the low-energy superstring theory representing static, spherical symmetric dyonic black hole is found. The solution is labeled by their mass, electric charge, magnetic charge and asymptotic value of the scalar dilaton. Some interesting properties of the dyonic black holes are studied. In particular, the Hawking temperature of dyonic black holes depends on both the electric and magnetic charges, and the extremal ones, which have nonzero electric and magnetic charges, have zero temperature but nonzero entropy. It is of interest to investigate how the properties of black holes are modified when the low-energy effective superstring interactions are considered. Recently, some new black hole solutions have been obtained in the low-energy superstring theories in which the gravitational field, dilaton field and gauge field are incorporated. We give a dyonic black hole solution of the low-energy effective superstring theory in which gravity is coupled to dilaton and corresponding gauge field. The structures and specific properties of dyonic black holes are similar to those of the conventional charged black holes, except for a purely electric or purely magnetic case. We

studied the special dyonic supersymmetric black holes with curved asymptotic backgrounds in higher-dimensional spacetimes of constant scalar curvature in the supergravity and superstring theory.



Extremal Dyonic Black Holes in Supergravity and Superstring Theory

We investigate extremal dyon black holes in the supergravity theory with higher curvature corrections in the form of the interaction coupled to the dilatino superfield, where the extremal dilatonic black hole is a particularly interesting model associated with the heterotic superstrings. In supergravity theory, the purely electric or magnetic black holes are supersymmetric and the electric-magnetic duality of this theory respects supersymmetry. The supersymmetric embedding in the supergravity theory of dyonic black hole must have more than one non-vanishing vector field in the supermultiplet. An intriguing possible explanation of the nonsupersymmetric nature of the dyonic black hole is the following: just as solutions which preserved different numbers of supersymmetries in supergravity but the same number were argued to be unrelated by duality transformations, the question can be raised as to whether the present embedding is related to another supersymmetric embedding by a duality transformation. That would lead us to speculate about the existence of a supergravity theory of which that duality would be a symmetry. We study several aspects of extremal spherical symmetric black hole solutions of

higher-dimensional supergravity coupled to vector and chiral supermultiplets with the scalar superpotential turned on the constructions. The extremal dyonic black hole can be regarded as a solution of a set of equations of motions such as the general field equation, the gauge field and the scalar field equations of motions by varying the supergravity action with respect to the curvature, gauge superfields, and scalar superfields on the spherical symmetric metric. Perhaps there are other explanations, possibly in terms of the bound state picture of extremal black holes, that make the theoretical speculations unnecessary. It has recently been shown that all possible embeddings of purely electric or purely magnetic higher-dimensional extremal black holes in supergravity must be related by duality symmetries of the supergravity theory and therefore must have the same number of unbroken supersymmetries in the higher-dimensional supergravity. Shortly afterwards it was discovered that, when the vector field is considered as one of the six vector fields present in the supergravity multiplet, there exists a choice of local supersymmetry parameter such that the supersymmetry transformation laws of the four gravitini and dilatini of this supermultiplet vanish, where exists a spinor such that the supersymmetry variation vanishes and the extreme dilaton black hole is purely supersymmetric. Below we shall discuss the conformal models for certain fundamental and dyonic superstring backgrounds, which, upon dimensional reduction, may be identified as supersymmetric extreme black holes. We shall give only the bosonic superstring theory with world-sheet supersymmetric interactions and the superstring-theory level in the corresponding dyonic configurations are described by superconformal models with the bosonic part in the interaction. Other supersymmetric saturated black hole solutions with the same values of electric charges but different short-distance structure are found by starting with a more general conformal model which can be viewed as an integrated marginal deformation of the model describing the superfields produced by oscillating superstring states of the free superstring spectrum with fixed values of the winding and momentum numbers. Then a general tool for calculating the entropy for extremal dyonic black holes is given.

based on the observation that the black-hole potential takes a particularly simple form in the supergravity case, which is fixed in terms of the geometric properties of the moduli space of the given theory. Finally, by exploiting the supergravity machinery introduced in the publications, we shall give a detailed analysis of the higher-dimensional solutions for the various theories of extended supergravity. The magnetic counterparts of the extremal electric black holes can be found by the duality transformation, or by considering the above fundamental superstring model as a six-dimensional background and applying the duality transformation in six dimensions. For fixed values of charges one expects to find a subfamily of supersymmetric saturated black hole backgrounds which all look the same at large distances but differ in their short-distance structure at scales of order of compactification scale where their higher dimensional superstring origin becomes apparent. On the other hand, the higher supergravity theory could encompass all known supergravities, in the spirit of the membrane theory.



Supersymmetric Black Holes in Fundamental Membrane Models

The higher dimensional black holes and membranes described in the current literature also appear naturally in the discussion of the membrane world model of large extra dimensions. It is clearly important in the membrane world context to find membrane black hole

solutions, both to shed light on membrane gravity itself and, more importantly, because observations of supersymmetric black holes might provide an exciting means of detecting extra dimensions. The membrane world scenario describes our eleven-dimensional world as a membrane that is embedded in a higher dimensional bulk and that supports all gauge superfields excluding the gravitational field that lives in the whole spacetime. There are many membrane world models in the cosmological context as well as descriptions of local self-gravitating objects. Particularly, black hole solutions on the membrane are interesting because they have considerably richer physical aspects than black holes in general relativity. This strongly suggests that supersymmetric extended object solutions of supergravity theories will not suffer from the type of instability recently found to afflict certain non-extreme extended object or black hole solutions of higher-dimensional gravity. It leaves open the interesting question of the stability of the different types supersymmetric black holes or their theoretical constructions with fundamental membranes. In the theory the metric includes all the known extreme, non-dilatonic, extended object solutions of higher-dimensional supergravity theories with fundamental supermembranes. These are the membrane solutions of eleven-dimensional supergravity, the self-dual membrane of ten-dimensional supergravity and the self-dual superstrings of six-dimensional supergravity. The membrane world description of our universe entails a large extra dimension and a fundamental scale of gravity that might be lower by several orders of magnitude compared to the fundamental scale. An interesting consequence of the membrane world scenario is hidden in the nature of spherically symmetric vacuum solutions to the membrane gravitational field equations which could represent black holes with properties quite distinct compared to ordinary black holes in four-dimensions. We discuss certain key features of some membrane black hole geometries, where such black holes are likely to have diverse cosmological and astrophysical ramifications. The cosmological evolution of primordial membrane black holes is described highlighting their longevity due to modified evaporation and effective accretion of radiation during the early

membrane world high energy era. Observational abundance of various evaporation products of the black holes at different eras impose constraints on their initial mass fraction. Surviving primordial black holes could be candidates of dark matter present in galactic haloes. The configurations of sources that give rise to the gauge fields in four dimensions are exactly of the form that they couple to the membranes extending along the supermanifold. We conclude a four-dimensional black hole is made from black membranes that extend along the internal directions. One finds the electric and magnetic charges of the four-dimensional black hole are due to membranes of different dimensionality. At strong coupling, the membranes under consideration gravitate and form a supersymmetric black holes. The first step towards a description of current equations for the time-dependent membrane solutions is to generalize the argument for supersymmetric black holes in supergravity theory to time-dependent membrane solutions, as this is the generic situation in supergravity theories. If we were to study the number of quantum mechanical ground states of the membrane system in the 'microscopic' regime, there is no reason to believe this number gives the entropy of the black holes as in the 'macroscopic' supergravity regime. However, there is a class of solutions for which the result is independent of the value of the coupling, namely for supersymmetric black hole solutions. Following that idea, the researchers successfully explain the entropy from a microscopic membrane picture for higher-dimensional supersymmetric black holes in the curved spacetime. These membranes are confined on submanifolds of higher-dimensional spacetime, where the supergravity interact and the superstrings can end on them. In particular, membranes of different dimensionality can form bound states and from the superstring perturbation theory, it is in certain cases possible to count the quantum mechanical degeneracy of a state with a given fixed number of membrane charges. The identification as membranes, suggests we can find an estimate for the black hole entropy by finding the number of quantum mechanical ground states that correspond to the given total membrane charge of the four-dimensional black hole in the supergravity approximation. However, there is an important caveat: superstring perturbation

theory and the supergravity description as a black hole are two different beautiful pictures. In terms of a typical number of membranes, one finds that the quantum gravity theory is valid and we can easily study membrane bound states when supergravity black hole picture is form of good approximation. By assuming the existence of a novel multi pronged superstring state for super particles interacting with membrane intersections in the higher-dimensional superstring theory, we are able to derive a quantum mechanical description of supersymmetric black holes. There was a conjecture that the higher-dimensional supergravity or superstring theory in the near horizon geometry of the fundamental membranes was equivalent to the conformal supersymmetric theory on these membranes. Although we will not deal with the microscopic point of view at all in this paper, it is important to mention that such an interpretation became possible after the introduction of membranes in the context of superstring theory. Following this approach, extremal black holes are interpreted as bound states of membranes in a spacetime compactified to four or five dimensions, and the different microstates contributing to the black hole entropy are related to the different ways of wrapping membranes in the internal directions. Let us mention that all calculations made in particular cases using this approach provided values for the black hole entropy compatible with those obtained with the supergravity, macroscopic techniques. The perturbative membrane picture of black holes can be used to count microstates and to derive the microscopic entropy. The fundamental membranes have a complementary realization as higher-dimensional analogues of extremal black holes. We have reviewed the concept of extremal black holes as it arises under conditions of supergravity in diverse dimensions. We present two supersymmetric intersecting membrane solutions of eleven-dimensional supergravity which upon compactification to four dimensions reduce to extremal dyonic black holes with finite area of horizon. The first solution is a configuration of three intersecting membranes with an extra momentum flow along the common superstring. The existence of supersymmetric extremal dyonic black holes with finite area of the horizon provides a possibility of a statistical understanding of the entropy from the point of view in superstring

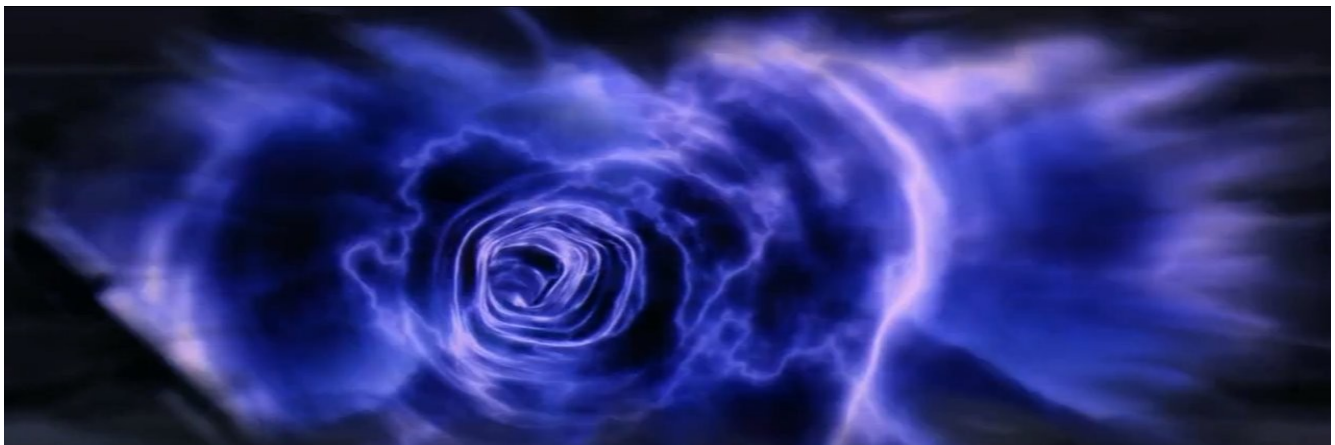
theory. One may hope to find a different lifting of the dyonic black hole to superstring theory that may correspond to a purely membrane configuration. A related question is about the embedding of the dyonic black holes into higher-dimensional supergravity or M-theory which would allow to reproduce their entropy by counting the corresponding states using the membrane approach similar to the one applied in the black hole case. The extremal black hole can be represented in M-theory by a configuration of orthogonally intersecting membranes with a momentum flow along the common superstring, or by configuration of three membranes intersecting over a point in the natural structure of supermanifold. Most of the configurations with four intersecting membranes are supersymmetric and have transverse the space dimension equal to two configurations with membranes intersecting over other membranes to preserve supersymmetry does not fit into eleven-dimensional spacetime. We have demonstrated the existence of supersymmetric extremal higher-dimensional configurations with finite entropy which are built solely out of the fundamental membranes of the corresponding theories and reduce upon compactification to dyonic black hole backgrounds with regular horizon. Namely, there exists an embedding of a four dimensional dyonic black hole into the higher-dimensional theory which corresponds to the combination of membranes only. This may allow an application of the approach similar to the one of superstring theory to the derivation of the entropy by counting the number of different excitations of the membrane configuration. Geometrically, we may have a two membranes with three black holes, each of the black holes attached to different higher-dimensional hyperplanes in which the membranes interact in the supergravity background. We need to examine a different configuration superspace where one replaces a number of disconnected membranes by a single multiply wound membrane swimming and living in the hyperspace. Our arguments for counting the microscopic states applies only to the configurations where membranes intersect over the superstring background in higher-dimensional curved spacetime. While the membrane state counting derivation of the entropy is relatively straightforward for the black holes, it is less transparent in the standard case, a

complication being the presence of a solitonic membrane in addition to a membrane configuration. Since superstring theory is expected to provide the consistent and finite theory of supergravity, we hope that within the context of superstring theory we might be able to address various interesting questions in supersymmetric black hole physics related to the black hole evaporation and the consequent information loss puzzle for models in diverse dimensions. It has also been proposed there that massive elementary superstring states themselves should be identified with supersymmetric black holes in supergravity and superstring theory. This shows that we have to be careful about applying the supergravity transformations on a supersymmetric black hole solution successively, but it does not rule out the possibility that suitable combinations of these transformations in the higher-dimensional interactions can be found which give rise to the membrane models construction and interpretation. In particular, study of the relationship between supersymmetric black holes, supergravity multiplets and the elementary superstring states requires us to construct the most general and universal supersymmetric black hole solution in the theory of fundamental membranes. We hope that the beautiful variants presented in this scientific article can be used to study the relationship between the different supersymmetric black holes, supergravity interactions in diverse dimensions and elementary superstring states in the spirit of fundamental supermembranes.

The Quantum Wormholes in Higher-Dimensional Theories with Fundamental Membranes

Wormholes are warps in the fabric of spacetime that connect one place to another in our universe or more abstractly and sublime one universe to another membrane universe in the hyperspace of the multiverse. If you imagine the universe as a two-dimensional sheet, you can picture a wormhole as a throat connecting our sheet to another one. In this scenario, the other sheet could be a universe of its own, with its own stars, galaxies and planets. The objects scientists think are black holes could instead be wormholes leading to other universes, a new study says. If so, it would help resolve a quantum conundrum known as the black hole information paradox, but critics say it would

also raise new problems, such as how the wormholes would form in the first place. Theoretically, wormholes are much better than black holes because all these problems with information loss don't exist in this case. Since wormholes have no event horizons, things are free to leave without first being converted into Hawking radiation, so there is no problem with lost information. They have since become accepted as a natural consequence of general relativity, which predicts that matter entering one end of the wormhole would instantly emerge somewhere else, so long as the wormhole is somehow propped open. This idea assumes the existence of a bizarre substance called phantom matter, which has been proposed to explain how wormholes might stay open. Phantom matter has negative energy and negative mass, so it creates a repulsive effect that prevents the wormhole closing. Phantom matter's negative mass would have the opposite gravitational lensing effect to normal matter, making any light passing through the wormhole from another universe or point in spacetime diverge, and emerge from it as a bright ring. Meanwhile, any stars behind it would shine through the middle. Overall, the wormhole theory is interesting, but not a breakthrough in explaining the origins of our universe, where our universe was created by a gush of matter from a parent universe, the theory simply shifts the original creation event into an alternate reality.



Quantum Wormholes

Spacetime wormholes are hypothetical objects in the general theory of relativity, where intense gravitational fields warp space and time to provide shortcuts from one part of our universe to another or more

special the route from our universe to some other universe. Physicists have not found solid experimental evidence that wormholes exist, but there are reasonably convincing theoretical arguments that strongly suggest that wormholes should be part of the theory of quantum gravity. In the quantum regime, on the other hand, and particularly in the context of the canonical quantum cosmology, quantum wormholes may be identified with a state or an excitation represented by a solution to the quantum gravity equation satisfying a certain boundary condition describing the wormhole configuration. It will be demonstrated that there indeed is a solution to the equation whose asymptotic behaviors satisfy the wormhole boundary condition stated above and hence can be identified with a wormhole wave function, namely a universe wave function for quantum wormholes. Our results can be construed as placing upper bounds on the actual allowed thicknesses of such layers of negative energy density. These results conclude that, unless one is willing to accept fantastically large discrepancies in the length scales which characterize wormhole geometries, it seems unlikely that quantum field theory allows macroscopic static quantum wormholes. The relation of the integral formulation of quantum gravity to string theory has long time been mysterious. While both the Euclidean and Lorentzian path integrals for gravitational theories have longstanding pathologies, by analogy with well-understood situations in quantum field theory, they can be used to inspire effects that may or may not be present in a true theory of quantum gravity. Thus, it is an extremely interesting question to see if such effects are present in string theory and examined in the situation of quantum wormhole. These should represent stationary points of the integral formulation of quantum gravity and one can try to understand them either through the rotation or as contributions to the interactions obtained by deforming the contour analogously to the usual stationary phase approximation for finite dimensional interactions. The quantum wormhole is one whose complete description requires quantum theory and more precisely the theory of quantum gravity. An example of a quantum wormhole is the ephemeral, submicroscopic wormhole of the sort that characterizes spacetime interactions. The mouths of quantum wormholes are many orders of

magnitude smaller than the smallest elementary particle and the wormhole is a special case of space warp. The physicists was the blessed people to imagine the vacuum state of the quantized gravitational field. They believed that the corresponding spacetime would at tiny length scales be a roiling froth that momentarily permits every conceivable spacetime geometry including wormholes. Unfortunately, the effort to create a theory of quantum gravity has not yet advanced sufficiently to permit anything approaching a complete description of spacetime interactions or of the quantum wormholes it is presumed to contain.



Traversable Wormholes

This is a part of the deep theoretical insight. The traversable wormhole would imply massive non-locality and this is forbidden in both descriptions, one with the wormhole and one with the entanglement. In recent years there has been considerable interest in the topic of traversable wormholes, solutions of Einstein's equations which act as tunnels from one region of spacetime to another, through which an observer might freely pass. Traversable wormhole spacetimes have the property that they must involve exotic matter, with the stress solution which violates the weak energy condition. Thus the energy density must be negative in the frame of reference of at least some observers. Although classical forms of matter obey the weak energy condition, it is well-known that quantum fields can generate locally negative energy densities, which may be arbitrarily large at a given point. A key issue in the study of wormholes is the nature and magnitude of the violations of the weak energy condition

which are allowed by quantum field theory. One possible constraint upon such violations is given by averaged energy conditions. Subsequently to the theoretical concept, several wormhole solutions were obtained and discussed within different contexts. However, it was present that the fledged renaissance of wormhole physics took place through the some research papers considered static and spherically symmetric traversable wormholes, and thoroughly analysed their fundamental properties. It was found that these traversable wormholes possess a stress-energy tensor that violates the null energy condition, a property that was denoted the exotic matter. So the choice of the non-traversable wormholes ignore the sign of any incompleteness of the proposal. Traversable wormholes are almost certainly prohibited by the laws of physics the scientists confirm this expectation while a new argument for the non-existence of traversable wormholes arises as a corollary of their work. Otherwise, the insight works in many spacetimes where the wormholes have technically different shapes and different number of dimensions, among other special things in the theory. They also claim that a description for excited wormholes exists on both sides, too. Tiny amounts of entanglement don't allow the quantum wormholes to be big and smooth, but that's not a defect of the proposal. It depends on a feature of the exotic matter that supports it. Specifically, it depends on what's called the equation of state of the exotic matter, how its pressure depends on its density. For exotic matter modeled more or less conservatively as massless particles of negative energy, the spacial type traversable wormholes are unstable. Although it is always possible to choose an equation of state that guarantees stability, this stability is not unlimited. Any wormhole will collapse to a black hole after a sufficiently large influx of positive energy. Conversely, any wormhole will expand ceaselessly after a suitably large influx of negative energy. While it has recently been shown that the wormhole traversable in principle can be held open with arbitrarily small quantities of exotic matter, it still appears that enormous quantities of exotic matter are required to hold open wormholes that are traversable by humans in a timely fashion. The possible explanation for dark energy is the supposition that the universe is awash in dark

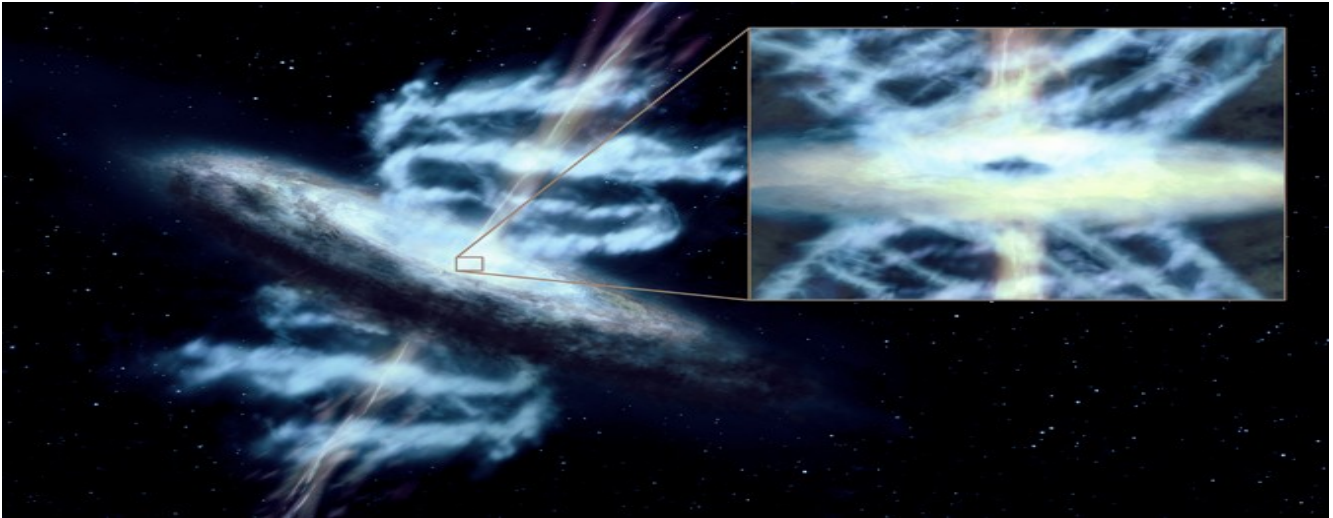
exotic matter and this is precisely the sort of matter required to sustain traversable wormholes. The stability analysis places constraints on the equation of the state of the exotic matter that comprises the throat of the traversable wormhole. Exotic matter is matter that violates an energy condition, where the traversable wormhole requires the anti-gravitating effect of exotic matter at its throat to counter the wormhole's tendency to inwardly contract. The researchers used a bound on negative energy density derived in four-dimensional spacetime to constrain static, spherically symmetric traversable wormhole geometries. They argued that the bound should also be applicable in curved spacetime on scales which are much smaller than the minimum local radius of curvature and the distance to any boundaries in the spacetime. The upshot of our analysis is that either a wormhole must have a throat size which is only slightly larger than the length, or there must be large discrepancies in the length scales which characterize the geometry of the wormhole.



Quantum Wormholes with Phantom Energy and Matter

One interesting aspect that we shall consider here is the possibility of sustaining traversable wormhole spacetimes via exotic matter made out of phantom energy. The latter is considered to be a possible candidate for explaining the late time accelerated expansion of the universe. This phantom energy has a very strong negative pressure and violates the null energy condition, so becoming a most promising ingredient to sustain traversable wormholes. Notice however that in

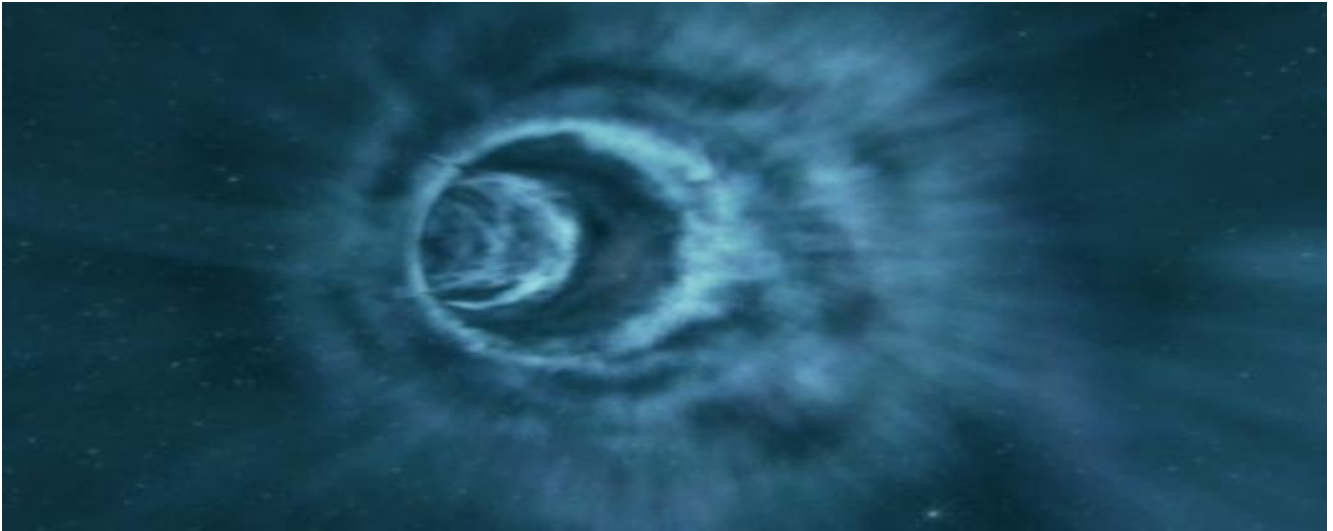
this case we shall use the notion of phantom energy in a more extended sense since, strictly speaking, the phantom matter is a homogeneously distributed fluid, and here it will be an inhomogeneous and anisotropic fluid. It is interesting to note that in the current publications is considered the possibility that the enormous negative pressure in the center of a dark energy star may, in principle, imply a topology change, consequently opening up a tunnel and converting the dark energy star into a wormhole. It should be mentioned that the stability of some specific wormhole static configurations also has been considered. Of course this fact is very speculative to this stage, but no observation can discard the existence of phantom energy. Nowadays we know that may be a combination of phantom and quintessence field could be the dominant component in the universe. The fact that phantom energy can be the source of wormholes is more than exciting, and give rise to investigate about the existence of stars made of this kind of matter. Phantom matter's negative mass would have the opposite gravitational lensing effect to normal matter, making any light passing through the wormhole from another universe or point in space-time diverge, and emerge from it as a bright ring. Meanwhile, any stars behind it would shine through the middle. Shatskiy suggests that his idea might offer a way for future space-based observatories such as Russia's planned Millimetron Project to look for wormholes at the centre of large galaxies. By using a properly generalized accretion formalism it is argued that the accretion of phantom energy onto a wormhole does not make the size of the wormhole throat to comovingly scale with the scale factor of the universe, but instead induces an increase of that size so big that the wormhole can engulf the universe itself before it reaches the big rip singularity, at least relative to an asymptotic observer. On the other hand, some extended theories of gravitation, such as supergravity and superstring theories, possess the vacuum states. Even within the framework of general relativity, a negative cosmological constant permits black holes with horizons topologically different from the usual spherical ones. These solutions are convertible to wormhole solutions by adding some exotic matter with the asymptotically flat wormhole solutions in a generic cosmological constant background.



The Wormhole Features of Black Holes

Today black holes are part of the basic toolkit of physicists and astrophysicists, and their existence in the real universe is taken for granted. It is, however, interesting to examine critically to what extent the current, or future, astrophysical data can observationally prove the existence of black holes. Indeed, black holes are sophisticated theoretical constructs with many different properties and each observational evidence usually concerns only one specific property. In this article, we consider a very simple type of black hole foil which includes the quantum wormhole. Though a wormhole does not have an event horizon, and differs, in principle, in several other important ways from a black hole, we shall show here that, if a certain parameter entering its definition is small enough, the wormhole is essentially astrophysically indistinguishable from a black hole. The advanced researchers considered a wormhole spacetime as a foil to the black hole, to learn to what extent the observational features of a black hole do really depend on the presence of an event horizon. Indeed, unlike a black hole, a wormhole geometry is globally static and does not have an event horizon. It was clear from the start that, as the two spacetimes have a nearly identical geometry for the black hole, they would have very similar closed geodesics, and would therefore be practically indistinguishable in astronomical observations that depend only on the external gravitational field. However, and more surprisingly, we found that many observational features that were thought to crucially depend on the presence of an event horizon

were well mimicked by a wormhole, if the parameter is sufficiently and exponentially small. This includes, the apparently irreversible accretion of matter down a hole, no-hair properties, quasinormal-mode ringing, and even the dissipative properties of black hole horizons, such as the finite surface. It remains interesting to keep in mind that most of the phenomenology of black holes does not really depend on the presence of an horizon, and also though this deserves more study that a wormhole could somehow mimic the black hole radiation, as well as may provide a simple way of visualizing the microstates storing the information apparently lost during a gravitational collapse. One would, however, need a more detailed model of the formation of a wormhole to address this is a black hole. Interestingly, there is a link between these two methods, when takes the value suggested in the classical wormhole bounce time scale becomes comparable to the quantum evaporation time of the black hole. The physicists were looking at how entangled black holes would behave. When the black holes were entangled, then pulled apart, the theorists found that what emerged was a wormhole, the tunnel through spacetime that is thought to be held together by gravity. The idea seemed to suggest that, in the case of wormholes, gravity emerges from the more fundamental phenomenon of entangled black holes. The final conclusion is that the possibly unique way of conclusively proving the presence of a black hole endowed with an horizon would be to observe its black hole radiation. And even this conclusion needs some qualification, because we shall see that some features of wormholes naturally tend to mimic the quantum spectrum of blackholes, so that it is possible that some to be defined wormhole formation mechanisms could lead to an black hole radiation. For instance, in many observations the black hole candidates are mainly picked either because their inferred mass exceeds some theoretical limit, or on the basis of their strong external gravitational field. Several authors have claimed that some observations have probed, or will eventually probe, more characteristic features of black holes, and notably the essentially defining existence of the quantum wormholes. The literature discusses how wormholes can lead to several interesting effects in the quantum theories of gravity with the present fundamental interactions.



Quantum Wormholes in Maximal Supergravity

In supergravity theory, the flat and charged Lorentzian wormholes in higher dimensions were obtained, where the wormholes are smooth everywhere, and connect two asymptotically flat spacetimes. Although these wormholes are not traversable geodesically, it was demonstrated in the literature that there exist traversable accelerated timelike trajectories across the wormhole. The physicists construct charged wormholes as solutions to infinite-dimensional supergravity coupled to a form field strength, together with the dilaton and gravitino in the higher spacetime dimensions. In this brief note, we reconsider the problem of finding quantum wormhole solutions to maximal supergravity in infinite-dimensions. We obtain a large class of smooth Lorentzian membrane wormholes in supergravities in various dimensions, where they connect two asymptotically flat spacetimes. The more intriguing situation is when there exists a wormhole in the bulk that connects smoothly to different supergravities. The researchers review important properties of the hypermultiplet sector of the quantum interaction with the wormhole in higher-dimensional supergravity models. We have seen that, in contrast to some claims in the literature, the supergravity theory has complex wormhole solutions for any higher dimension. The theoretical physicists construct the instanton and wormhole solutions in supergravity theories with hypermultiplets, which are the supersymmetric manifolds of superfields. The analytic continuation of the hypermultiplet action,

Involving pseudoscalar axions, is discussed using the approach originally developed in physics which determines the appearance of boundary terms. In particular, they investigate the conditions obtained by requiring the interaction to be positive-definite once the boundary terms are taken into account. Instantons and wormholes determine potentially important non-perturbative effects in superstring theory. Both can be obtained as saddle elements of the quantum interaction of the corresponding low-energy supergravity. Instanton and wormhole solutions have been discussed for various theories and dimensions, in particular the dilaton theory, the universal hypermultiplet in supergravity and general hypermultiplets in the four-dimensional theories with superfields. It might be best to assume that a string solution for wormholes exist and see what the consequences are for the development of the theory. Wormholes are similar to black holes, but where the event horizon is replaced by a membrane of some type of quantum field which causes the supergravity of the fundamental membrane. The new studies build off previous studies of wormholes, in which researchers suggested wormholes may be responsible for the communication between supergravity and superstring theory. The researchers derive and study a class of cosmological and wormhole solutions of low-energy effective string field theory which is connected to supergravity.



Quantum Wormholes in Superstring Theory

Superstring theory is tackling the problem of wormhole's existence.

Indeed, it seems that superstring theory can make stable wormholes, without any addition of exotic matter. Not much, although the brane world concept that has emerged from superstring theory might provide a framework through which we might begin to understand how wormholes connect to parallel universes. In the membrane world scenario the universe is a eleven-dimensional supermembrane, embedded in a higher-dimensional spacetime called the bulk, rather like a sheet of paper floating in the superspace. Parallel universes can be imagined as a stack of slightly separated parallel sheets or membranes floating in superspace. It's clear, then, that a wormhole that links different regions in the bulk would necessarily link different parallel universes. Another connection is the slight possibility that the projection of a specific superstring theory of the bulk onto the membrane representing our universe might have an interesting effect. Specifically, it might contribute to the stress energy of the membrane in a way that simulates the presence of exotic matter. Or to state the matter in the theoretical fashion, there is still a chance that wormholes in superstring theory might enjoy the benefit of exotic matter without exotic matter. The wormhole is constructed by cutting and joining two spacetimes satisfying the low energy superstring equations with the dilaton and the gravitino fields. In spacetimes described by the superstring, the dilaton energy momentum need not satisfy the weak or dominant energy conditions. In the cases considered here the dilaton field violates these energy conditions and is the source of the exotic matter required to maintain the wormhole. There is also a surface stress-energy, that must be produced by additional matter, where the spacetimes are joined. It is shown that wormholes can be constructed for which this additional matter satisfies the weak and dominant energy conditions, so that it could be a form of normal matter. Charged dilaton wormholes with a coupling between the dilaton and the electromagnetic field that is more general than in superstring theory are also briefly examined. The theoretical physicists discuss the wormhole effective interactions in superstring theory, thought of as a sum over higher-dimensional field theories on different world sheets. The effective interactions are calculated in the dilute wormhole

approximation, initially by considering the functions on higher-genus surfaces, and then by calculating the effect of a complete basis of wave functions on scattering amplitudes for a surface with the boundary. The sum over wormholes is equivalent to having a world sheet of trivial topology and summing over different spacetime and matter-field backgrounds. To leading order these consist of the massless fluctuations, since the tachyon cancels out when a sum is done over different spin structures going through the wormhole. Using the lowest order effective superstring action they found an axionic wormhole which however has an infinite supergravity interaction. More recently an instanton has been found which describes a tunneling between zero-energy vacua of superstring theory. This situation is somehow uncomfortable because if superstring theory has to solve the puzzles of supergravity it should also provide us the natural framework for studying processes like the formation of quantum wormholes in higher-dimensional spacetime.

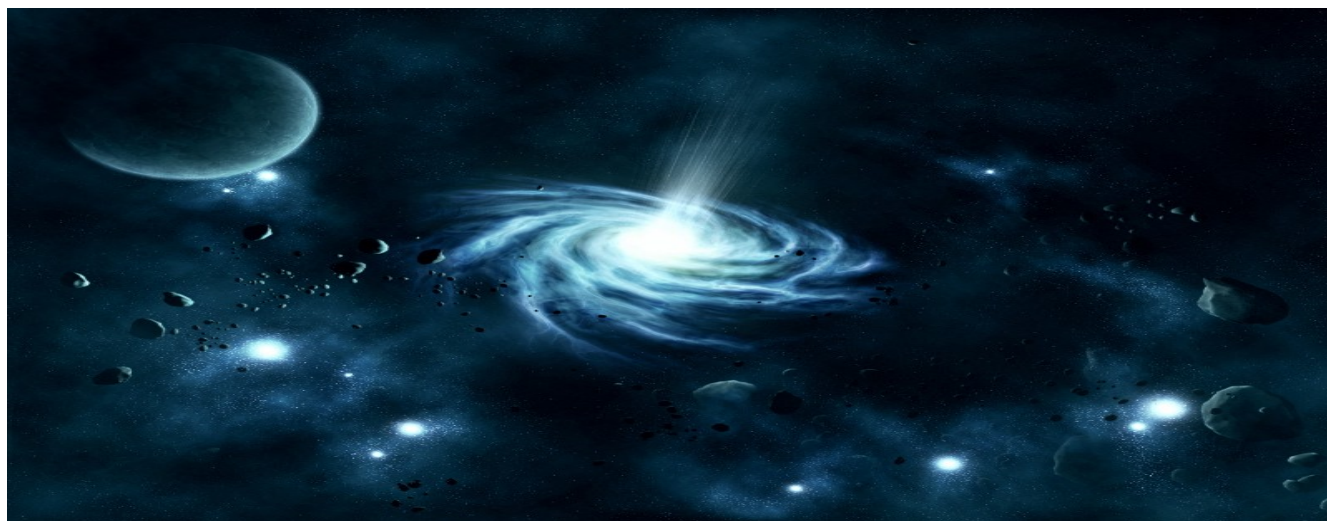


Expanding Quantum Wormholes in Higher-Dimensions

The present article investigates the possibility and naturalness of expanding wormholes in higher dimensions which is an important ingredient of the modern theories of fundamental physics, such as superstring theory, supergravity, Kaluza-Klein, and many others special investigations. One of our motivations for considering wormhole solutions in an expanding cosmological background refers to the inflation theory where the quantum fluctuations in the inflaton

field are considered as the seed of large scale structures in the universe. As mentioned above, the non-trivial topological objects such as microscopic wormholes may have been formed during inflation and enlarged to macroscopic ones as the universe expanded. We also explore the possibility that these higher-dimensional wormholes satisfy the null energy condition. Non-trivial topological objects such as microscopic wormholes may have been formed through the quantum interactions and enlarged to macroscopic size during inflation and in the subsequent expansion of the universe. Indeed, if most of the wormholes in the quantum foam survived enlargement through inflation, then the universe might be far more inhomogeneous and topologically complicated than we observe. Indeed, postulating higher-dimensional spacetimes is an important ingredient of modern theories of fundamental physics. In this context, the existence of higher dimensions may help construct wormhole solutions that respect energy conditions. In particular, in a cosmological set up, microscopic, dynamical wormholes produced in the early universe may be inflated to macroscopic scales and thus be at least in principle astrophysically observable. In this work, by assuming a homogeneous matter field, which is the energy density depending only on the time coordinate, which holds in the standard cosmology, we arrived at interestingly simple and exact solutions. More specifically, we considered a particular class of wormhole solutions corresponding to a spatially homogeneous scalar curvature. The possibility of obtaining solutions with normal and exotic matter was explored and we found new solutions including those that satisfy the null energy condition in specific time intervals. In particular, in five dimensions, we found solutions that satisfy the null energy condition everywhere. The equations of motion are governed by the system of a scalar coset coupled to infinite-dimensional gravity. Among the solutions, we find a large class of smooth Lorentzian wormholes that connect two asymptotic flat spacetimes. The solutions, there is a large class of new smooth Lorentzian wormholes. The role that wormholes play in superstring theory has been studied recently in the context of their correspondence. In Lorentzian signature, wormholes that connect two asymptotic spacetimes appear unlikely, and disconnected boundaries

can only be separated by horizons. Because it appears that exotic matter can support stable wormholes in four-dimensional spacetime, we will assume without taking the trouble to extend the four-dimensional analysis, that such wormholes are possible as well in spacetimes of higher dimensions. We shall, moreover, assume the possible existence of stable higher-dimensional wormholes even when the higher-dimensional spacetime is curved and the interactions of the quantum fields exists. The most salient feature of this encounter, when it is close, is that the black hole in the bulk induces a black hole in the membrane. Here we consider instead an encounter between the membrane and the quantum wormhole in the bulk of the membrane. The black hole case suggests that such an encounter will have an analogous result, which postulate that the wormhole in the bulk will induce in the general case the new wormhole in the membrane.



Quantum Wormholes in The Fundamental Membrane Models

In the context of the special membrane scenarios, the researchers considered the possibility of wormholes in the bulk and their likely manifestations in any large-scale membrane that encounters them in the higher-dimensions of the hyperspace. In order for such wormholes to exist, the bulk must possess matter that violates the null energy condition. This need not imply the existence in the bulk of an oft-considered dilatonic scalar field that would violate the spirit of the membrane-world proscription of off-membrane matter. This matter can instead consist of a fluid of closed microscopic

membranes. This would only be possible if such membranes were quantum mechanically stable and possessed of exotic matter, which include in the quantum wormhole. Modeling such a membrane as a matter dominated domain wall in the higher-dimensional solution, the scientists have derived its equation of motion using the standard thin-shell formalism and have canonically quantized the system whose extremized field solutions generates these equations. This procedure coupled with the uncertainty principle leads to an effective potential, whose minima correspond to the quantum ground states in the wormhole. We have shown that such minima exist for several choices for the equation of state of the membrane matter and have focused specifically on membranes whose matter content dominates their intrinsic tension. The recent membrane solutions that not only describe new sorts of black holes and naked singularities, but also contain the special type of quantum traversable wormholes. There is nothing to prevent the higher-dimensional bulk spacetime from containing various other membranes in addition to hosting our universe, presumed to be a positive-tension membrane. In particular, it could contain closed, microscopic membranes that form the boundary surfaces of void bubbles and thus violate the null energy condition in the bulk. The possible existence of such micro membranes can be investigated by considering the properties of the ground state of a pseudo equation describing membrane quantum dynamics in the superspace. If they exist, a concentration of these micro membranes could act as a fluid of exotic matter able to support macroscopic wormholes connecting otherwise distant regions of the bulk. Were the membrane constituting our universe to expand into a region of the bulk containing such higher-dimensional macroscopic wormholes, they would likely manifest themselves in our membrane as wormholes of normal dimensionality, whose spontaneous appearance and general dynamics would seem inexplicably peculiar. This encounter could also result in the formation of baby universes of a particular. This exact specification of the bulk spacetime induces precise values for the stress energy on the membrane. However, the special symmetry of the exact bulk solution normally limits this approach to global descriptions of the membrane. An exotic fluid composed of countless

the null energy condition which violating the micro membranes is only possible if there exists a stable or metastable state in which such membranes are at least a couple of orders of magnitude smaller than the macroscopic wormhole throats of interest. To determine whether this is the case, we will employ the thin-shell formalism to consider the quantum dynamics of a closed micro membrane that violates the bulk null energy condition. Rather than supposing that this micro membrane is itself a wormhole throat, we shall instead regard it as a bubble surrounding the void. Like the negative-tension membrane in the theoretical construction, it is a boundary for the bulk spacetime in the diverse higher-dimensions. Having argued for the possibility of wormholes in the bulk supported by a fluid of exotic void bubbles, I have briefly considered an encounter between such a wormhole and our universe. An analogy with the encounter between bulk black holes and membranes together with an intuitive understanding of the geometry of the encounter suggests that wormholes in the bulk will induce wormholes in the membrane. The calculation and analysis on the details of the encounter merits support the separate investigation and research. We might prefer the possibility if we have in mind a multi-membrane-world in which the collapse of a star establishes a bridge between two previously separate membrane-worlds. We find that there are twelve classes of solutions, including the previously known extremal or nonextremal fundamental membranes. We also find new smooth membrane wormhole solutions plus the study on the curvature properties of these solutions and in particular, the researchers focus on the wormholes and demonstrate that they are not traversable geodesically but traversable with certain timelike trajectories, as in the case of the previously known wormholes. In the theory have obtained the most general spherically symmetric membranes in the previous configurations and find the solutions with appropriate parameters describe smooth wormholes that connect two asymptotic regions in the higher-dimensional superspace. We have obtained their masses, linear momenta, as well as the membrane charges measured in each asymptotic region. The situation becomes much more complicated when the symmetry group belongs to exceptional groups, which can arise in lower-dimensional maximal

supergravities. It is of great interest to obtain all of the most general spherically symmetric membranes with all supergravities in diverse dimensions.



Quantum Wormhole Connections to Parallel Universes

The wormhole is a short passage in spacetime that directly connects two universes or two distant regions within the same universe. Beside being hypothetical shortcuts in spacetime and consequently useful for inter-universe and intra-universe travel, they were found to possess other intriguing applications, such as, the usage for time-travel and investigating the interior of a black hole, amongst the others constructions of the wormholes. The researchers created a configuration in flat space of a universe-membrane and a parallel anti-universe-membrane connected by the wormhole. At this stage, large amount of energy is transferred from anti-membrane to our own universe membrane. At second stage, the wormhole dies and there is no channel for flowing energy into our universe. In this condition, inflation ends and the cosmological redshift results reduced with lower velocity. With decreasing separation distance between the two universe membranes, a tachyon is originated. It grows and causes the formation of another wormhole. At this stage, the late time acceleration starts and the cosmological redshift accelerates to lower values. Accordingly, the destructive positive feedback loop of virtual particles circulating through the quantum wormhole, a result indicated by semi-classical calculations, is averted. A particle returning from the future does not return to its universe of origination but to a

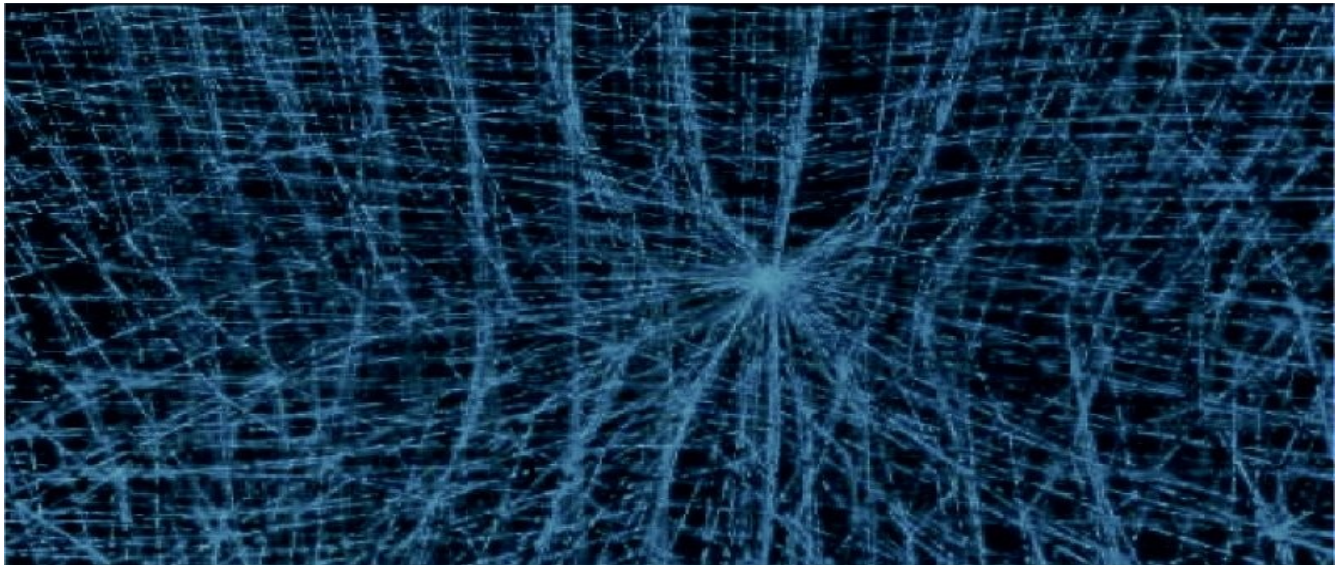
parallel universe. This suggests that the wormhole with an exceedingly short time jump is a theoretical bridge between contemporaneous parallel universes. Because the quantum wormhole introduces a type of nonlinearity into quantum theory, this sort of communication between parallel universes is completely real. They do in the sense that people from different universes or from distant parts of the same universe can both enter the black hole and meet each other. The meeting will likely be interrupted, however, by the violent deaths of both parties in the black hole's singularity. In turn, all the black holes found so far in our universe—from the microscopic to the supermassive—may be doorways into alternate realities. According to a mind-bending new theory, a black hole is actually a tunnel between universes, special type of wormhole. The matter the black hole attracts doesn't collapse into a single point, as has been predicted, but rather gushes out the hole at the other end of the black one. According to the new equations, the matter black holes absorb and seemingly destroy is actually expelled and becomes the building blocks for galaxies, stars, and planets in another parallel reality through the quantum wormhole tunneling. What is new here is an actual quantum wormhole solution in quantum gravity that acts as the passage from the exterior black hole to the new interior parallel universe, which was involved in the new study. Much attention has been paid in the last decades to wormhole physics, especially to traversable wormholes. They may in principle be used by humans to travel between universes or to distant parts of the same universe. Violations of the weak energy condition and null energy condition are supposed to occur at the throat of a traversable wormhole. Wormholes are topological tunnels that connect two universes or two distant regions of the curved spacetime in the fundamental membrane. To imagine two universes, think of two membranes floating near each other. The traversable wormhole connecting them would be like a short drinking straw glued between them that would allow an ant to crawl from one membrane to the other. The resulting multiverse has a very non-trivial spacetime structure, with a multitude of eternally regions connected by wormholes. Thus, one may adopt the approach of minimizing the usage of the phantom and exotic matter. In this context, a plethora of solutions have been

investigated, using a wide variety of theoretical approaches. More specifically, in rotating solutions it was found that the exotic matter lies in specific regions around the throat, so that it is possible for a certain class of infalling observers to move around the throat as to avoid the exotic matter supporting the wormhole. Using the thin shell formalism, solutions where the exotic matter is concentrated at the throat have also been extensively investigated. In the context of modified gravity it was shown that one may impose that the matter threading the wormhole satisfies the energy conditions, so that it is the higher order curvature terms that sustain these exotic geometries. Astrophysical and cosmological signatures have also been explored in the recent literature. The ability to create a traversable wormhole is well beyond current human technology. It would require the enlargement of one of the many submicroscopic quantum wormholes believed to exist within any volume of space. In the context of the quantum problem in the presence of a wormhole we examine whether this is compatible with the self-consistency of physics. We derive a self-consistency condition in which the classical limit corresponds to known results for the general quantum problem in a wormhole spacetime and that suggests that some fine-tuning of initial conditions might be necessary. More specifically, the energy density of the graviton contribution to a classical energy in the wormhole background is considered as a self-consistent source for wormholes. The existence of wormholes in the universe is very interesting because they could be highways to visit stars and galaxies, otherwise it will be impossible to go enough far away to visit other worlds, other parallel universes.

The Hidden Symmetries in Higher-Dimensional Curved Spacetime

The existence of the representations for supersymmetric theories in curved spacetime was associated, due to wide experience in the creation of higher-dimensional models, with some hidden symmetries. The symmetry enhancement of the hidden symmetry arises when the spacetime curvature is obtained after reduction of a specific choice

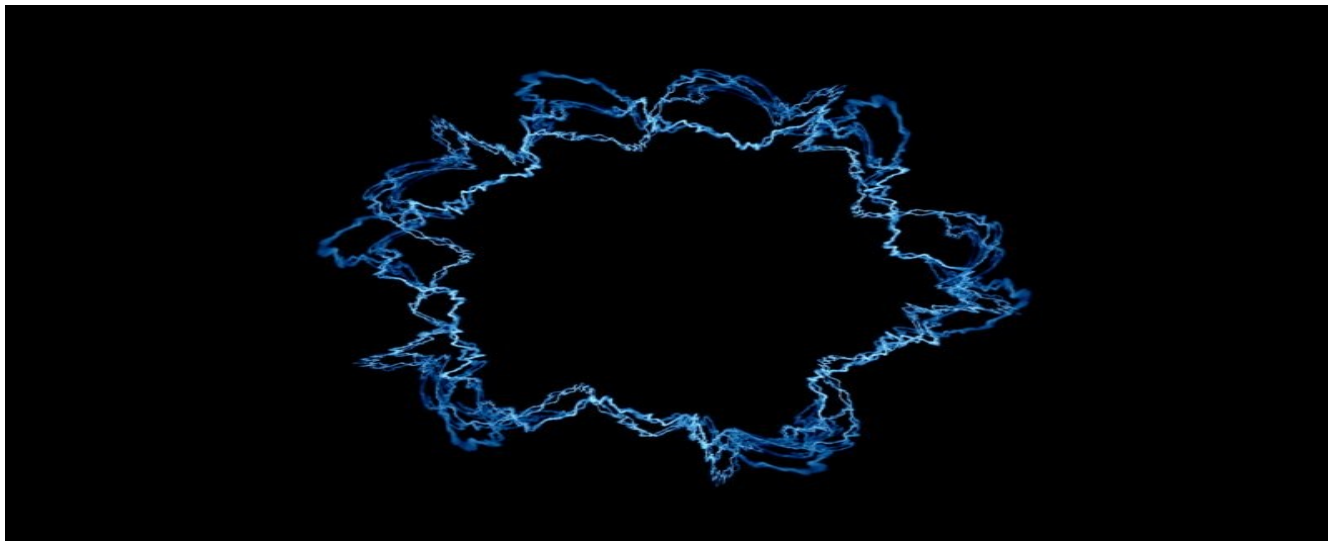
of couplings in the higher-dimensional theory. These remarkable properties of higher-dimensional curved spacetime solutions offer new perspectives in investigation of hidden symmetries of other unknown spacetimes structures. An essential fundamental tool of modern physics is the identification and exploitation on new types of symmetries, which themselves can be hidden symmetries. The scientists investigate additional hidden symmetries of higher-dimensional curved spacetime that has a very symmetric appearance. The symmetry is firmly embedded in the laws of physics, but is hidden from our view because the particular state in which we find the universe is not invariant under this symmetry. Contemporary attempts to construct unified field theories have largely focused on the search for new and hidden symmetries of nature. Though this general structure establishes the connection with the more traditional geometric approaches the spacetime perspective adds the additional insight that different configurations of layers are connected through the hidden symmetries of higher-dimensional spacetime. Recently, a new development has occurred in the field, with the realisation that for the gravitational theories that have been studied most the dynamics of the gravitational field exhibits strong connections with the geometry of spacetime, suggesting that these might be hidden symmetries of the theory. The resolution of these puzzles with the hidden symmetries clarifies some of the other questions of the research approach.



Hidden Symmetries in Supergravity Theory

One motivation for undertaking of this article of the hidden symmetries is the theory of supergravity. It is common lore that the appearance of large hidden symmetries in supergravity is tantamount to the presence of supersymmetry. It is a celebrated feature of eleven-dimensional supergravity that it exhibits a chain of the hidden symmetries when it is dimensionally reduced. It is interesting to study if the hidden symmetries of the lowest order supergravity interactions are preserved by these higher order derivative corrections. The connection between hidden symmetries and supersymmetry of the supergravity theories comes with the higher-dimensional interactions. Supersymmetry fixes the value of the couplings between all the fields in a multiplet, including the self-couplings. The prime instance of this phenomenon can be seen in maximal supergravity in eleven spacetime dimensions where interact the supergravity multiplet. In maximal supergravity, hidden symmetries have been successfully lifted to eleven dimensions, and recent work has uncovered tantalizing hints of exceptional geometric structures associated with these liftings. Recent examples include interesting models of the membranes, cosmological models, and methods developed for the study of the dualities of M-theory. Concerning the hidden symmetry in question, there are so far only partial results, namely a construction of the bosonic part of the model using a decomposition and a corresponding construction of eleven-dimensional supergravity as part of the aforementioned more general study of reductions to lower dimensions. Illustrations of this conjecture are also discussed in the context of cosmological solutions to eleven-dimensional supergravity. This important work has opened the way to many further fruitful investigations in theoretical cosmology. The hidden sector coupled to the observable sector through interactions of supergravity strength. This was exactly the picture of hidden sector supergravity and supersymmetry is potentially in the hidden sector. It naturally appeared in the framework of superstring theories. The new aspect of this picture is the fact that now hidden and observable sector become separated geometrically. Thus hidden sector supergravity breakdown now becomes the breakdown of

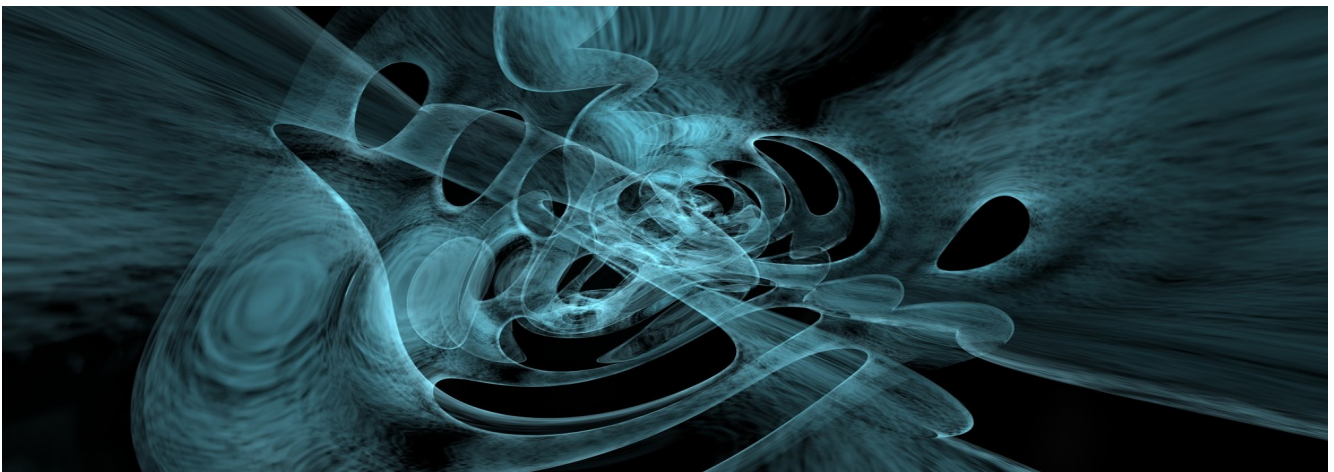
supergravity at a hidden supermembrane. Nevertheless, all matter including superfields from the hidden sector still interact through the spacetime curvature of supergravity. Some researchers constructed a low energy supergravity model consistent with all cosmological and particle physics constraints, by omitting some of the usual simplifying assumptions in the hidden sector. In the latter case hidden and observable sector become separated geometrically and supersymmetry is broken dynamically on a hidden wall of the sector.



Hidden Symmetries in Superstring Theory

There reasons to believe that we are yet to unveil hidden symmetries which are the higher symmetries in superstring theory. Therefore, it is argued that discovering and understanding such higher symmetries will provide us with deeper insight of superstring theory. Subsequently, we examine these hidden symmetries in a quantum context and the study is just the first step to explore the hidden symmetries in superstring theory. It is quite natural to presume that superstring theory will encode the hidden symmetries in their totality. Superstring theory goes even further with higher excitations of the string providing an infinite sequence of possible states. This may be why the idea of higher spin symmetries is now seen as a possible solution to the problem. Higher-dimensional superstrings have an invariance, at the quantum level, under a hidden non-compact symmetry. These symmetries are explicitly broken only by minimal gauge couplings, as it happens in the theory of supergravity. The

researchers discuss the dynamical origin of these symmetries at the level of the model describing the motion of a given superstring in an arbitrary background. The hidden symmetries are a spacetime manifestation of the non-compact, generalized duality rotations for the underlying interacting higher-dimensional field theory. The corresponding symmetry transformation law of the higher-dimensional background fields can then be constructed. This result justifies our previous consideration on higher hidden symmetries from the generalized model point of view, and is a general feature for higher massive levels. There are the following indications supporting the idea for hidden symmetries in superstring theory. More than ten years ago it was realized that the theories which now are considered as describing a low energy limit of superstring theories do possess some hidden symmetries. There is the conjecture that the duality symmetries should be pieces of the hidden gauge symmetry in superstring theory. Dualities and hidden symmetries of superstring theory are closely related to each other. It has been shown that dualities require the modification of superstring theory to M-theory. The algebraic structure of M-theory is encoded in hidden symmetries of the superstring theory low-energy effective actions. All the visible symmetries in superstring theory are remnants of a much larger hidden symmetry so that only different residual parts of it are seen in different hidden sectors. Superstring theory goes even further with higher excitations of the superstring providing an infinite sequence of possible states. This may be why the idea of higher hidden symmetries is now seen as a possible solution to the problem.



The Hidden Symmetry Structure of M-theory

The theoretical physicists present and discuss hidden symmetries of M-theory, its feedback on the construction of the M-theory effective action, and a response of the effective action when locality is preserved. In particular, the locality of special symmetries of the duality-symmetric supergravity constraints the index structure of the dual to gravitino field in the same manner as it is required to separate the levels of generators subalgebra from the infinite-dimensional hidden symmetry of supergravity theory. Substantial progress in this direction was recently achieved within the conjectured, at early stages of the development of the algebraic structure of M-theory. This structure is realized as the very extension of the hidden symmetry algebra of dimensionally reduced eleven-dimensional supergravity. The duality-symmetric eleven-dimensional supergravity interaction can be considered as a good starting point in searching for the least interaction principle of hidden constituents of M-theory which are encoded in the symmetry algebra. Many years ago it was found that the dimensional reduction of eleven-dimensional supergravity to lower dimensions leads to the emergence of unexpected hidden symmetries, notably in the reduction to four non-compactified spacetime dimensions. Since their role in the greater scheme of M-theory was postulated, there has been intense renewed interest in the hidden symmetries of supergravity. While most work has, understandably, centered on the maximal eleven-dimensional theory and its various dimensional reductions, with recent work ranging from the gauging of subgroups of the global exceptional groups to the identification of new vacua to possibilities for enlarging the hidden symmetries even further, there have also been results of a more general scope. Notably the work showing in the most systematic manner yet how the hidden symmetries arise in successive dimensional reduction has been generalized to other dimensional reductions to lower dimensions. Understanding the symmetries of supergravity is therefore important for reaching a satisfactory formulation of M-theory. The symmetry enhancement of the hidden symmetry arises when the spacetime curvature is obtained after reduction of a specific choice of couplings in the higher-dimensional theory admits an even larger gauge group.

The scientists investigate additional hidden symmetries of higher-dimensional curved spacetime that has a very symmetric appearance. However, then they will not cancel for the higher order curvature terms. This is a generic feature of the dimensional reduction of supergravity actions and is related to the observation in according to which higher curvature terms are associated with the weights of the hidden symmetry rather than its roots which occur in the usual parametrization of the superspace. It is interesting to study if the hidden symmetries of the lowest order supergravity interactions are preserved by the higher order derivative corrections. These ideas have the potential of providing the theoretical framework for a truly unified theory of gravity and matter, which can provide an explanation for the known low-energy gauge theory of matter and predict its full particle content. The insight is that seemingly distinct focal textures are in fact related in a precise way, through a hidden symmetry revealed by analogy with supergravity theory. The extension to a curved setting raises the question of whether or not a similar hidden symmetry exists there, perhaps exploiting ideas from supergravity, superstrings and the structure of the higher-dimensional curved spacetime, and indeed this turns out to be the case. New development has occurred in the field, with the realisation that for the gravitational theories that have been studied most the dynamics of the gravitational field exhibits strong connections with the geometry of spacetime, suggesting that these might be hidden symmetries of the theory.

Multiverse, Parallel Universes and Realities

Multiverse or meta-universe is a hypothetical set of multiple possible universes, including our universe, which together represent the entire physical reality. The different universes within a multiverse are called parallel universes. The structure of the multiverse, the nature of each universe within it and the relationship between the various constituent universes, depend on the specificity of the multiverse hypothesis. In this situation, parallel universes are also called

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alternative universes, quantum universes, parallel worlds, or alternate and parallel realities. Multiverse is a hypothetical set of finite and infinite possible universes, including our universe in which we live and build our reality. Taken together, these universes contain everything that exists: the integrity of space, time, matter, energy, and physical laws and constants that describe them. Of the many possible worlds follow the evidence and interpretations, physicists and mathematicians are directed to study the implications of the theory in depth. Also these mental journeys suggest and imply that there are parallel universes parallel to our own, and we coexist with them in the so-called hyperspace build our multiverse. In physics and cosmology parallel universes are hypothetical collection of identical or different universes, including unique and hypothetical universes that coexist with the known universe, but can grow and live in radically different laws of physics. Typical deep and specific group of parallel universes is called a multiverse, although this term can be used to describe the possible parallel universes that represent reality. While the terms parallel universe and alternate reality are generally synonymous and may be used interchangeably in most cases, there is sometimes an additional connotation of the term alternative reality, which means that the reality is a variant of our own. Physicists refer to this phantom theory as a theory of everything. Quantum physicists believe they are on the trail of finding this to be the final theory constructed to obtain deep and perfect picture of the physical reality.

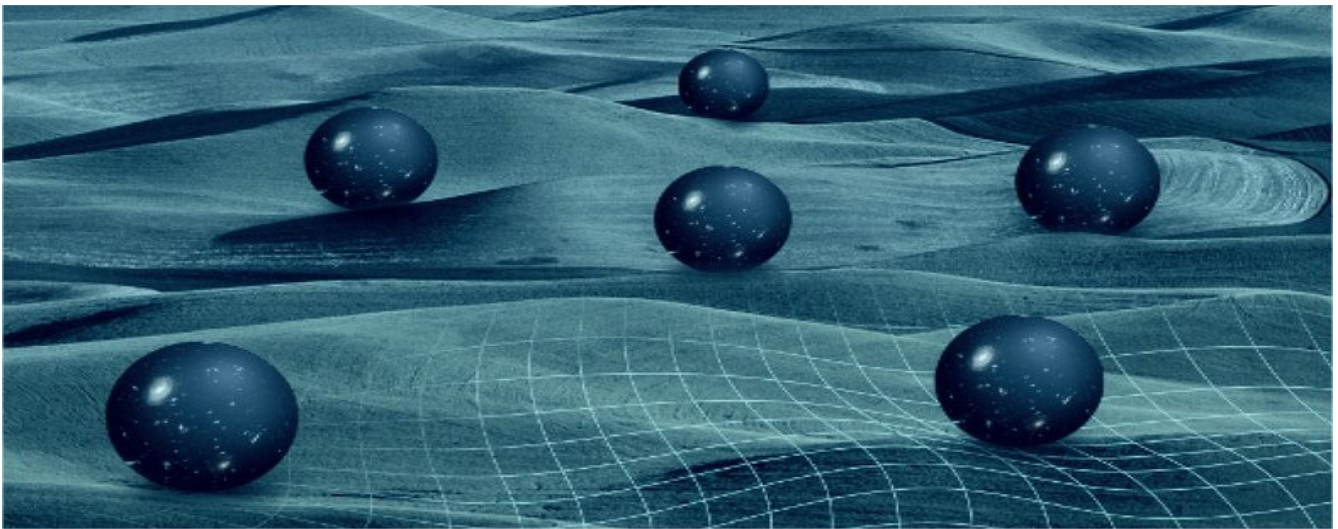


The Existence of Mirror Parallel Universes

The theory allows for the existence of many parallel universes where the laws of nature are slightly different from ours and describe another type equations. From a theoretical point of view and considered among travel through dimensions to other universes may be possible, but this limit is the amount of energy needed for this task. Although this is a huge obstacle for us, maybe there are civilizations that managed to extract harvest energy from antimatter and to travel to other universes - and one of those universes can be ours. But such travel to other universes with different physical laws of nature can create some restrictions on universal space tourists and to confuse their plans. While it is theoretically possible to travel through hyperspace, the amount of energy required for the implementation of this is beyond our technology at this point. For example, just to go into hyperspace requires a huge amount of electron volts energy. In the beginning, when the Big Bang created our universe, some theoretical physicists believe that also created the opposite of our mirror universe where time moves in the opposite direction. From our point of view and position in space, the time in parallel universe is reverse. But two separate groups of prominent physicists working on models of the multiverse, which consider the initial conditions that could have created the arrow and the general direction of time, and seems to show that in these universes, time moves in two different directions. There may be a parallel mirror world that has the same particle physics as the observable universe and connecting only gravity. The demand for limits of nucleosynthesis in the mirror universe means that the sector of the mirror must have less temperature than usual. For this reason, the development of mirror universe must significantly deviates from the standard cosmology, as far as crucial eras as baryogenesis, nucleosynthesis are concerned and they are given significant importance for the development of this parallel world mirror of us. Starting from inflationary scenario that could explain the different initial phases of both sectors are studied history and time of the early mirror universe. We have shown that mirror universes can provide a significant contribution to the energy density of the multiverse, and thus they could represent the component of dark

matter and dark energy making up a mirror universe. Unfortunately, we can not exchange information with physicists living in the mirror universe to combine our observations. Above all, if both worlds are equally microphysics described by quantum interactions life should be possible also in the mirror sector. However, there can be many options to facilitate the cosmological scenario of two parallel worlds with future data accuracy regarding the large-scale structure of the observable universe mirror. In fact, M-theory allows for many different internal spaces - different universes, each with its own special set of laws of nature. Possibility of formation of universe through gravity will drain the matter in our universe, with some of its local laws of nature to seep into our universe. The theory could explain the effect of dark matter, where areas of the universe are heavier. Following the theory problems about the big bang are replaced by the eternal cosmic cycle where dark energy is no longer a mysterious unknown quantity, but rather itself extra gravitational force that drives the universe to universe or interaction of membrane with membrane. Dark matter does not seem to fall into the dense gravitational wells, because it will be blurred by the physical distance between different universes and the fact that stars and galaxies would not exist in exactly the same place in each universe. Matter in many parallel universes must be kept together and evolve into large scale, but only part of their gravity will reach our universe. If a large mass of dark matter occur in more massive universe, as measured by its momentum and the subsequent measure its gravity will be a good indicator that there is the issue of leakage of gravity in other universes. In the event that there is no mismatch between inertia and gravity, then it is very likely existence of invisible matter interactions in our universe. If dark matter is the outer membrane of each universe, then gravity will have to pass through two membranes - membrane surrounding each universe, thereby creating a double layer of dark matter and dark energy eventually. There will be no communication between the two universes except the gravitational pull on a parallel universe sister of our universe, which can cross the slightest difference. Given that the two universes are surrounded by dark defend regardless forming membrane universes we can expect

both drivers have different properties, just as universes contain and possess qualities quite different from those in our universe. This sets the stage for studies of at least two different types of dark matter, each forming a membrane encapsulated and combined in a given universe. The membrane theory may explain the low gravity. However, this idea requires at least one of the extra dimensions should be much larger than a certain size. It can be shown that in the absence of energy, gravity will be located in the membrane and will behave exactly as predicted by general relativity. But at sufficiently high energy, gravity no longer be located in the membrane and in the higher dimensions will behave in a way included with dramatic changes in the gravitational dynamics. There have been attempts to visualize the intersection of two membranes passing through any other field actually creating our space as they do in reality. Separate universes manifest, interact and participate in each membrane, presumably their penetration through the escaping gravity. But the established theoretical picture of the many worlds is not just a theory that tries to explain the multiverse. Also it is not the only option, which suggests that there are universes parallel to our own.

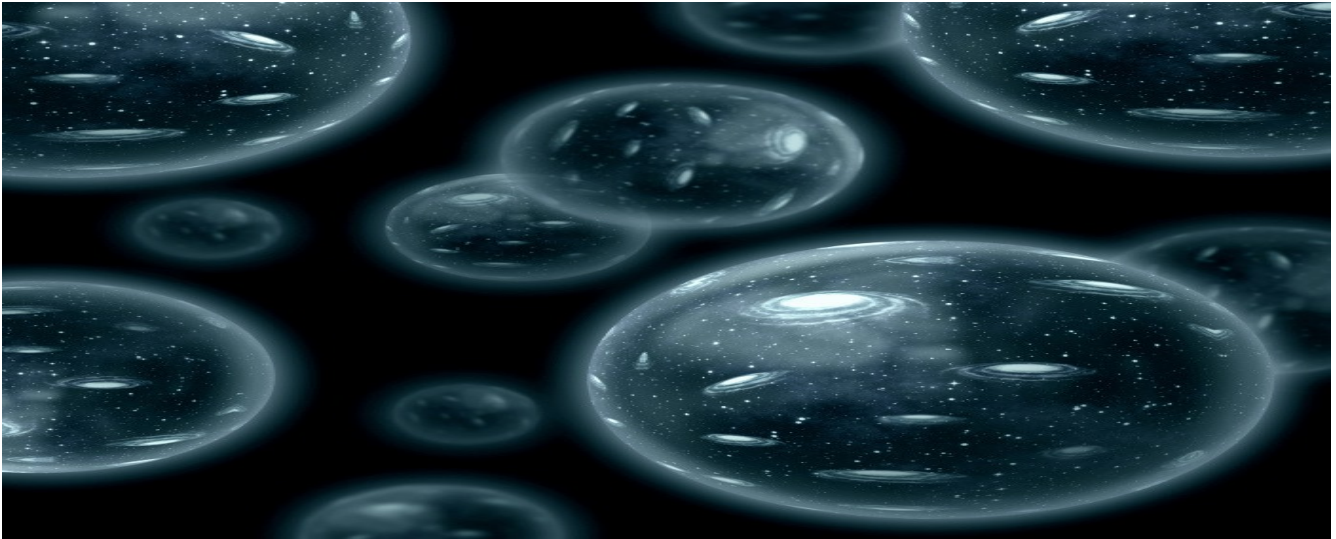


Hyperspace of Parallel Universes

The theory of hyperspace in which they live and interact with all parallel universes has generated so much excitement in the world of theoretical and mathematical physics. Theoretically it developed

unique idea emphasizing that the theory of hyperspace, you may be able to unite all the known laws of nature in one theory of the multiverse. Thus the theory of hyperspace may be the crowning achievement for thousands of years of research, the unification of all known fundamental interactions and describing our offer models of different parallel universes. Despite this possibility many implications of this discussion are purely theoretical, traveling through hyperspace ultimately can ensure the practical application of all options, travel to a parallel universe in order to preserve and save intelligent life, including the death of our own universe. In the final seconds of the death of our universe, intelligent life can escape from collapse by escaping into hyperspace as inhabited new and unknown parallel universe. Perhaps the most common use of the concept of parallel universe in science fiction is the concept of hyperspace. Use the science fiction concept of hyperspace often refers to a parallel universe that can be used as a quick shortcut for interstellar and intergalactic travel. Models for this form of hyperspace vary locations in the map of the multiverse, provide different points of entry and exit in a parallel universe of space travelers through various portals. Travel time between two points within the multiverse of hyperspace is much shorter than the time to travel to similar items in our other universes. This may be due to different rates of transition, at different speeds, whereby the course of time to develop, or to the similar points in hyperspace multiverse simply distributed more closely to one another. Sometimes hyperspace is used to denote additional higher dimensions. In this model, it is believed that the universe can be built in some higher spatial dimensions and that traveling in this higher spatial dimensions of a spaceship is not a problem to move great distances in overall dimensions. While this idea relies on new dimensions, it is not an example of a parallel universe or another type of reality. It's true scientifically plausible use of hyperspace and time to its comprehension and decoding. While parallel universe can be used by the concept of hyperspace, the nature of parallel universe often not investigated and its physical laws are not established. Since general relativity and quantum theory are giant worlds for ourselves, not surprisingly, to unite these two theories in

building larger and unifying theory physicists are provided many new effects, the main among them is hyperdimensional spacetime. By way of construction of the theory physicists give a crystal clear explanation of such huge mathematical concepts such as non-Euclidean geometry, Kaluza-Klein theory and supergravity, the everyday tools of quantum and string theorist. Some of the pioneers in the field of superstring theory, which states that the main components of our universe are not quarks, protons and electrons but much smaller entities called strings or superstrings that vibrate and interact in ten dimensions of the hyperspace whose vibrations in different resonances occur in elementary particles. After the field the writer of science fiction or occultist to hyperspace was recently shown to be the only kind of space in which the laws of modern physics can be explained satisfactorily and comprehensively. Amazingly enough, many of the phenomena whose explanations are prevented physicists and cosmologists can now be fully understood with the help of ten and eleven dimensions included in hyperspace, and elegantly presented by supergravity, superstring theory and supersymmetry. Multiverse theory suggests the existence of parallel universes, just like our universe and others with various fundamental laws. All these universes are connected via hyperspace. Indeed, they branch off from ours, and our universe is branched off from the other parallel universes. Within these parallel universes, the actions and manifestations in life have had different results from those we know. Species that are extinct in our universe have evolved and adapted in others. In other universes, we humans may have disappeared and are replaced by a completely unknown species. The thought boggles the mind and yet, it is still understandable. Notions of parallel universes or dimensions that resemble our own have appeared in works of science fiction and have been used as explanations for metaphysics, for a physicist this is a disaster possibly risk his future career, presenting the theory of parallel universes and realities. A significant breakthrough was the defeat of common sense over theories of four dimensions and the victory of the theory of hyperspace in the identification and examination of higher dimensions of spacetime. The theories have been studied including various fundamental dimensions.



The Truth Encoded in the Multiverse

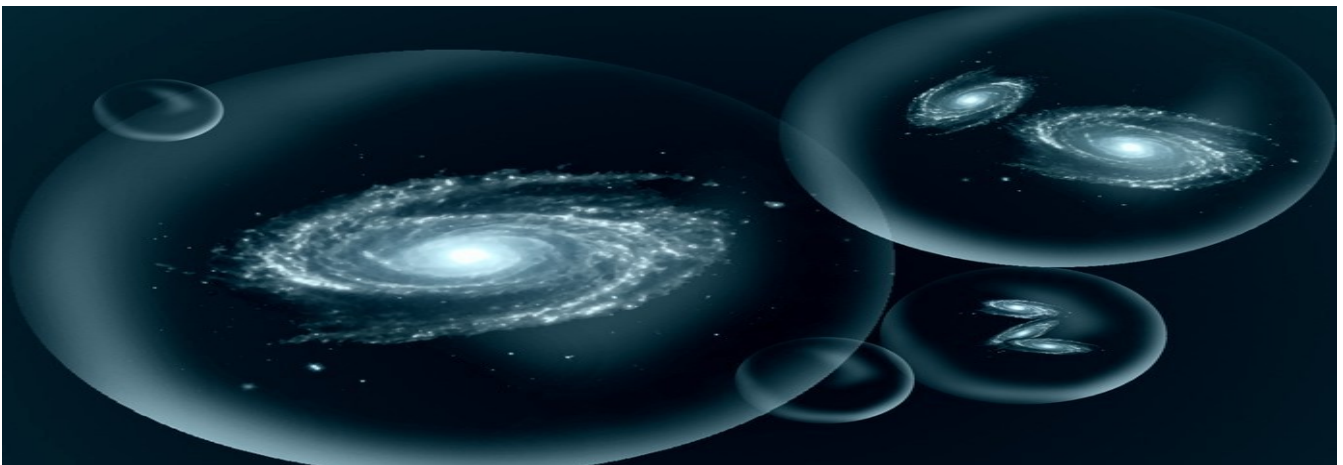
String theory recognizes the huge number of decisions describing membrane universes with different physical properties. There is another approach that can be followed and take us to exceptional results. The idea is to use our theoretical model of the multiverse to predict natural constants for which we expect to be measured in our local region of the multiverse. If constants vary from one universe to another parallel membrane, their values can not be predicted with certainty, but we can still make statistical predictions. We can draw from theory values of constants, which probably can be measured by a typical observer in the multiverse. Therefore, the forecast assumes that such values should be observed in our local part of the multiverse. Multiverse offers a very appropriate and possible explanations for many of the unique observations we have made on our own universe. Some of these multiverse models are science-ups for decades, while others are just starting to gain traction in our imagination and follow the development of science. Today physicists argue that this problem moving ideas like the multiverse from physics to metaphysics, from the world of science with this of philosophy. Some theoretical physicists say about their area that needs colder consideration, the need for hard evidence and worry about where the lack of evidence leads to erroneous models or hypotheses. According to the theory of parallel worlds, the emergence of intelligent design in our universe is the result of fundamental blocks that are collected, combined and

manually configured finely life and evolution of our universe, and such processes occur in the billions of other universes living in hyperspace constructing the multiverse.

The Baby Universes in Higher-Dimensional Models with Ghost Membranes

The behavior of baby universes has been an important ingredient in understanding and quantifying the supergravity, superstring theory and equivalently the higher-dimensional membrane models of supergravity coupled to matter and other special fundamental interactions. The proposed resolution present the picture that if one includes arbitrarily high order polynomials of the superfields there are infinitely many states of a baby universe provided one allows it to be arbitrarily large. The main idea of the baby universe theory is that our universe can split into disconnected pieces due to quantum gravity effects. Baby universes created from the parent universe can carry from particle or string interactions, or some other combinations of particles and fields, unless it is forbidden by the conservation laws. The strong robustness of the baby universe theory leads the thought towards the idea of the random dynamics of the membranes that fundamental physics seems with random construction. Recently a new look on quantum gravity and cosmology has attracted a lot of research interest which created the baby universe theory. The baby universe is normally a small closed universe which liberates itself from the bigger parent universe. A baby universe is defined as a simply connected region of the spacetime surface whose boundary length is much smaller than the root of its area in higher-dimensional curved superspace. This definition is meant to capture, in purely intrinsic terms, the intuitive picture of a baby universe as an membrane like region of the higher-dimensional surface attached to it by a small neck. The thickness of a neck will be defined as the length of the loop located at the thinnest point of the neck. Thus, to determine the thickness we need to identify, given a closed loop on the spacetime surface encircling the neck of a baby universe, where the

length of this loop becomes a minimum. The first correction to the theory structure comes from configurations where the parent universe splits into two by creating the new baby universe. The parent universe still ends up carrying charges corresponding to the membranes on which it had originally. The physicists find that the non-perturbative quantum terms and interactions can be organized into a sum over baby universes with new exclusive features. They find that half of baby universes preserve one set of supercharges and the other half preserve a different set. As a consequence, the total universe is not in the current state, but it is still stable since different baby universes are spatially disjoint in the hyperspace. In particular, all these universes are dual to a single supersymmetric theory of the membranes in the hyperspace of the parallel universes. The next leading correction comes from the configurations with three different universes, where the second universes splits of the baby universe. Generalizing this to the baby universe expansion, was interpreted in the theory as a squared of a wave function in the quantized superspace given as a coherent superposition of baby universes. The membrane charges are distributed among the baby universes in such a way that the total charges are conserved. Otherwise, no entanglement among the universes is found in this case, and all the states allowed by the charge conservation are summed with the same weight within a sector of a given number of baby universes.

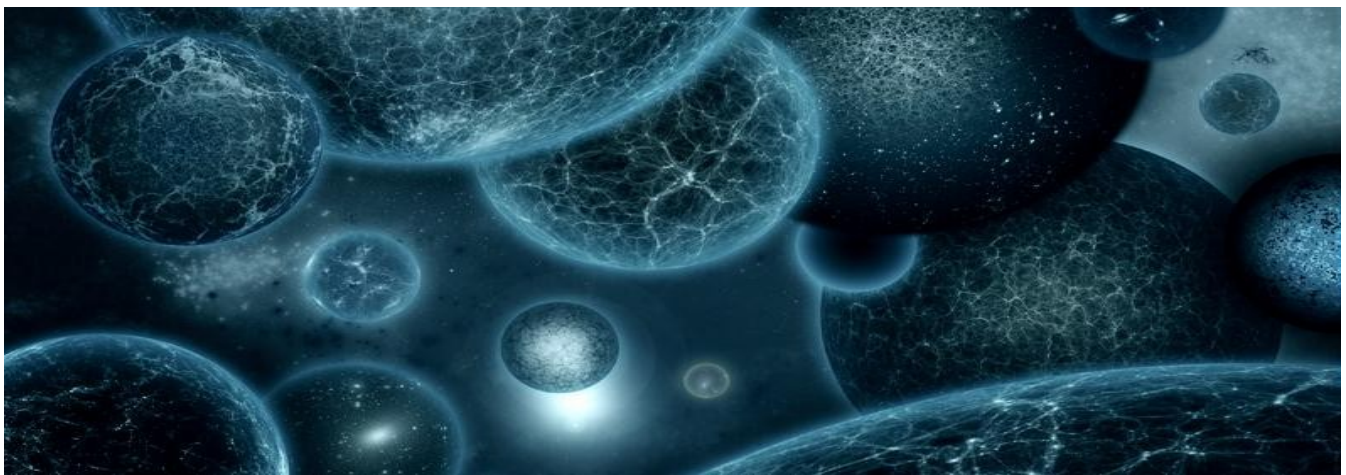


Quantum Cosmology with Baby Universes

Recently a new look on quantum gravity and cosmology has attracted

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entanglements of baby universes which appear in the quantum corrections to the formula for the entropy of extremal black holes in superstring theory compactified on the local supermanifold defined as the vector bundle over an arbitrary genus higher-dimensional spacetime surface. Non-perturbative terms can be organized into a sum over contributions from baby universes, and the total wave function is their coherent superposition in the quantized superspace. We find that half of the universes preserve one set of supercharges while the other half preserve a different set, making the total baby universe stable. There are no other source of entanglement of baby universes, and all possible states are superposed with the equal weight. Generalizing this to the baby universe expansion, was interpreted in the theory as a squared of the wave function in the quantum cosmology given as a coherent superposition of baby universes. The membrane charges are distributed among the baby universes in such a way that the total charges are conserved. Otherwise, no entanglement among the universes is found in this case, and all the states allowed by the charge conservation are summed with the same weight within a sector of a given number of baby universes. The many universe system in quantum cosmology can describe either a multiverse made up of parent universes or the spacetime landscape formed by popping baby universes.

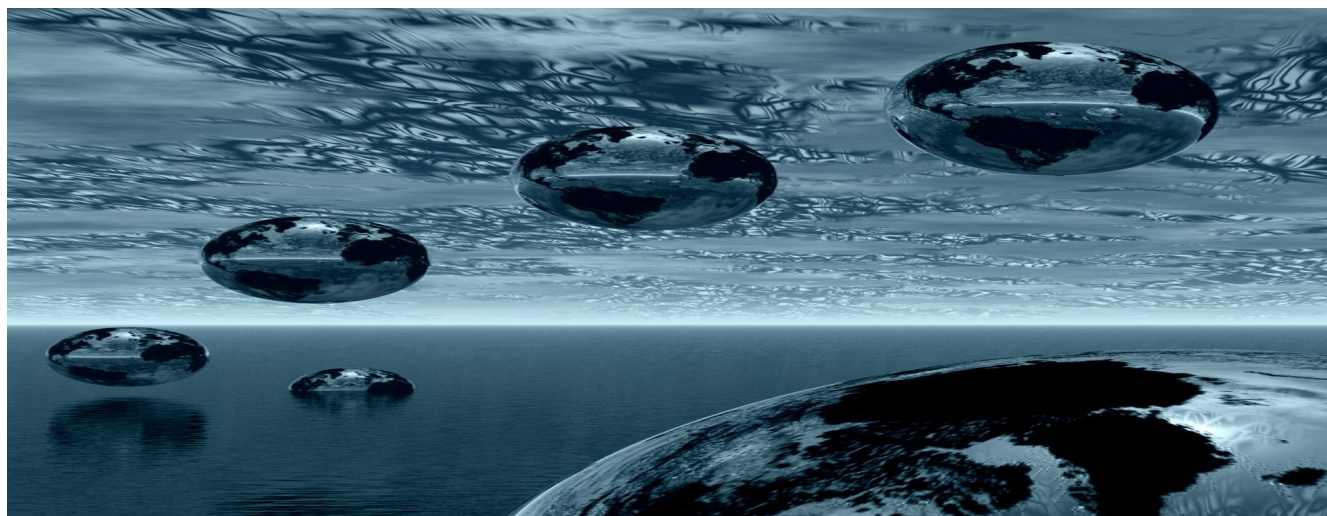


Supergravity Theory of Baby Universes

All the states in the baby universes are supersymmetric with interesting fundamental interactions of the supergravity multiplet and

different types of superstrings. However, by the same token, the mirror baby universe preserves opposite supersymmetry with anti-states in the supermanifold. Since the baby universes are disconnected, the entire configuration is still stable. The local region of baby universes in the hyperspace is a non-compact supermanifold which is the total superspace of the sum on two line gauge bundles over the hyperspace for some local fundamental interactions. However, one important feature present in higher-dimensional supergravity is missing in the simplest superstring model. We find that bare energy is not conserved in the higher-dimensional models due to the emission of baby universes, and that the probability of this process is finite even for local distribution of matter in the parent universe. We present a scenario suggesting that the non-conservation of bare energy may be consistent with the locality of the baby universe emission process in the higher-dimensions and the existence of the long ranged dilaton field whose source is bare energy. This scenario involves the generation of supergravity interactions in the parent universe. The localization is due to supergravity with the supersymmetry preserved by either membranes depends on their position on the supermanifold, and the anti-membranes on one pole preserve the same supersymmetry as the membranes on the second pole. In a baby universe, the superstring interaction came about from summing over the membrane states, and the anti-topological one over the anti-membrane states constructed from the higher-dimensional supergravity. Equally well, the baby universes of the preceding section can, under this new physical interpretation of the relevant mathematics, be used to investigate finite volume universes with boundary. The bulk of the physical universe now lies in the range, and we deduce the existence of a large class of stable baby universes with boundary, and an equally large class of unstable baby universes that either collapse to singularity, or explode to provide arbitrarily large universes. Note that these particular exploding universes in supergravity are quantum universes, and are not suitable cosmologies for our own universe. There is a specific trick that clarifies the situation with baby universes in the theory. Take the supermanifold with membrane boundary and make a second copy, then sew the two manifolds together along their

respective membrane boundaries, creating a single manifold without boundary that contains a membrane, and exhibits the supersymmetry on reflection around the membrane. Because this new supermanifold is a perfectly reasonable with the boundary supermanifold containing a membrane which is the baby universe, the gravitational superfield can be analyzed using the usual formalism of supergravity theory in higher-dimensional curved spacetime. It ensures that the supergravity computation in the current equations matches with the gauge theory computation of the current interaction where we only count the quantum bound states of baby universes with wrapping of the curved superspace. In summary for the supergravity case, all of these baby universes, which were investigated within the supergravity community more with a view to understanding the limitations of the theory than in the expectation that they actually exist in reality, are now seen to automatically be part and parcel of the membrane models currently being considered as the phenomenological models of current empirical reality.



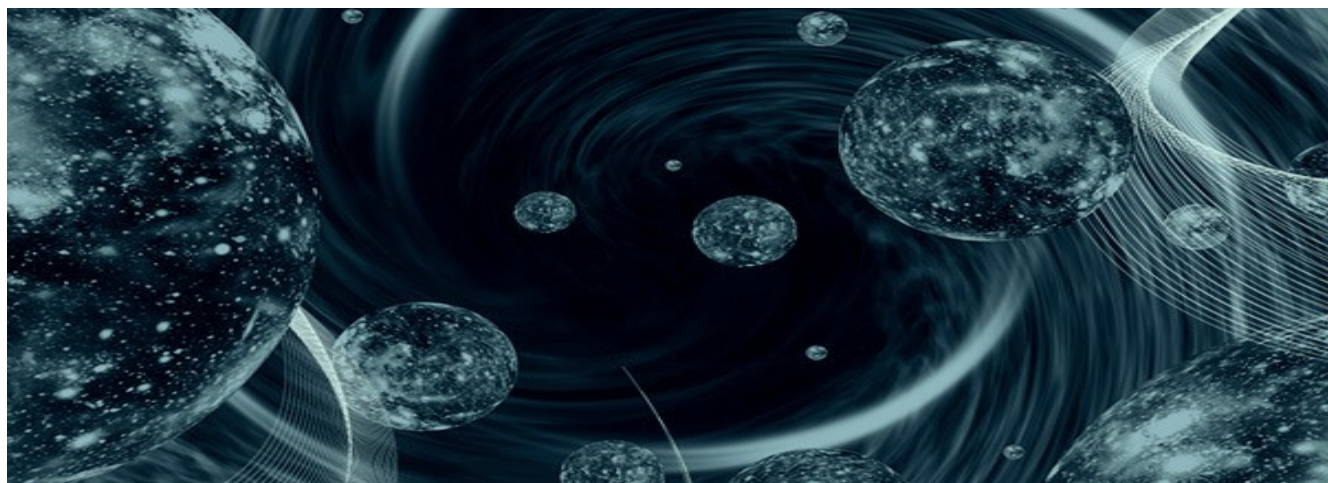
Baby Universes in Superstring Theory

The long standing issue of the possible role of topology changing transitions and baby universes may be naturally discussed in the superstring theoretical framework. The special feature of higher-dimensions which is useful for the study of baby universes is that some models admit their interpretation as superstring theories in higher dimensional target superspace. The researchers consider the

simplest fundamental state of the parent universe, which can be interpreted as containing just two dressed matter particles, and analyze the emission of baby universes by this state in the lowest order of superstring perturbation theory. They find that this emission always occurs with non-conservation of energy of matter in the higher-dimensional parent universe and then proceed to the explicit calculation of the emission rate. Surprisingly, the scientists find that the rate is unsuppressed even for localized distribution of matter in the parent universe, in spite of the long range field this matter produces. Then conclude by presenting a scenario showing that the non-conservation of bare energy of matter may be consistent both with locality of the emission process and with the presence of long ranged field where in this scenario, the mass is conserved at the expense of the generation of supergravity fields due to the emission of a baby universe. The parent universe in the higher-dimensional state can emit a baby universe which is a universe with small energy of matter particles where in infinite-dimensional language this process corresponds to the emission of a low lying superstring state into the infinite-dimensional superspace. In that case the emission of a low lying state would not necessarily require the change of the level of the heavy superstring. In other words, the emission of a baby universe would not necessarily require non-conservation of bare energy in the higher- dimensions. The emission of a baby universe always occurs with non-conservation of the higher-dimensional bare energy of matter in the parent universe. Making use of the gauge for the construction of quantum states, we considered at the very fine quantum level the simplest state of the parent universe that contains one left-moving and one right-moving dressed matter particles with large quantum wave numbers where the collisions of these particles may eventually induce the emission of baby universes. If the relevant quantum numbers of the baby universe higher-dimensional momenta of the superstring are large enough, the emission process is local in the parent universe. The results find that bare energy is not conserved in the higher-dimensional models due to the emission of baby universes, and that the probability of this process is finite even for local distribution of matter in the parent universe. The present scenario

suggesting that the non-conservation of bare energy may be consistent with the locality of the baby universe emission process in the higher-dimensions and the existence of the long ranged dilaton field whose source is bare energy. This scenario involves the generation of supergravity and superstrings interactions in the parent universe. For the actual calculation of the rate of the emission of a baby universe with low-lying superstring states by a parent universe with excited superstring in the state the physicists explicitly consider the emission of a tachyon, although the analysis plus the current results as the same for the emission of the supergravity gravitino field and different superstrings in the baby universes. The emission of a baby universe due to the collision of the higher-dimensional superfields with wave numbers has a chance to be local if the characteristic conformal time of the process of emission. To address this issue, more refined model than that of closed superstrings in critical dimensions, is needed for the creation of superstrings models of baby universes. A particularly the higher-dimensional model where the mass of matter fields produces long range effects, is the supergravity with matter that has been widely discussed from the point of view of black hole and wormhole physics. Here we take a different attitude and consider the emission of baby universes, so we simplify the model as much as possible. In particular, we set the number of matter fields and it has been argued that the emission of baby superstrings should lead to the loss of quantum coherence for the universal observer at the parent superstring. Independently, it has been argued on general grounds that the energy non-conservation is inevitable in modifications of quantum mechanics allowing for the loss of quantum coherence. Hence, the emission of the higher-dimensional baby universe by a parent universe has an interpretation from the infinite-dimensional point of view as the emission of a light superstring state by a highly excited superstring state, in complete analogy to the current observations. This process, in the leading order of string perturbation theory, is tractable both qualitatively and quantitatively in particular, one is able to analyze whether it is accompanied by non-conservation of bare energy in higher dimensions and whether its rate is large unsuppressed part when baby universes are emitted locally in higher-dimensional

parent universe. This provides a concrete realization, within superstring theory, of effects that can be interpreted as the creation of baby universes.



Membrane Models with Baby Universes

The membranes can form the quantum bound states with membranes wrapping in the configuration superspace. In the supergravity theory the quantum bound states of these objects is computed by the full supersymmetric interaction of the membrane theory refers to the fact that the zero modes corresponding to center of mass motion of the membranes are removed in the super trace of baby universes. The current research show that these are also a consequence of charge conservation, this time for charges of the non-compact membranes that can form the quantum bound states with the other types of membranes. These are also a consequence of the non-compactness of the supermanifold, because they correspond to having different boundary conditions at infinity of the hyperspace. Note first of all that the net membrane charge is conserved when the baby universes split, elegantly create the membranes and anti-membranes along with the participation in hyperspace. Moreover, even though in the first universe we have both the types of membranes, the effective membrane charge of either is positive. Correspondingly, the two kinds of membranes are mutually interact with themselves. The summed discrete parameters that shift the supersymmetric moduli in the baby universes are defined with the language of the hyperspace of parallel universes. The membranes are wrapping the boundary of the

higher-dimensional superspace on the spacetime surface direction and extending in the two directions of the fiber in the higher-dimensional curved spacetime. The part amplitude requires specifying three representations, corresponding to boundary conditions on the three pictures for the baby universes. More precisely, at each puncture for each baby universe, we will get as many open superstring moduli as there are the membranes, in this case infinitely many baby universes. However, only the center of mass degree of freedom will get fixed by the membrane charge, as the differences between the holomorphic supermanifolds ending on various membranes have zero intersection with the gauge bundle of the states in local interaction. There factorization of the current quantum interaction was a consequence of localization of membranes and anti-membranes to the poles of the supermanifold in a near horizon geometry of the black holes in M-theory compactification on the spacetime supermanifold. The localization is due to supersymmetry, the supergravity interactions preserved by either membranes depends on their position in the hyperspace, and the anti-membranes on one pole preserve the same supersymmetry as the membranes on the other pole. In the baby universe, the topological superstring function came about from summing over membrane states, and the anti-topological one over the anti-membrane states. Going from the standard to an anti-baby universe these assignments should naturally flip, as the membranes and anti-membranes get exchanged. This exactly leads to the exchange of the local quantum states and interactions we have seen above in the baby universes. In particular, note that the charges of the membranes need to be of the same sign for the membranes to be mutually interact with the different quantum states. With more than one universe, this structure is duplicated, setting the supersymmetric charges to zero which induces correlations between the different vector states of the current baby universes. The charges of these membranes in all the universes have to add up to zero, just as in the parent universe, and this induces correlations. In the current case of study, these membranes and correlations associated to them were absent, as they would violate the higher-dimensional symmetry of the base spacetime surface. Moreover the theory find that no other source of correlations

between different baby universes, for any higher-dimensional manifold.



The Ghost Membranes of Baby Universes

The ghost membranes are pairwise interactions between the tops of the higher-dimensional seas in hyperspace, with the fundamental interactions between the chiral and anti-chiral amplitudes of the quantum states in different baby universes. Suppose we just created a baby universe, so the local hyperspace in the multiverse increased by one new parallel universe. If the new baby universe is in general state and effective membrane charge in it is of the form, the ghost membranes in it are along the fibers of the spacetime. Thus, the ghost membranes are along the line gauge bundle where the membranes would have been in the multiverse. Its interaction with the parent universes depends only on whether they are in general or anti-state in the hyperspace. The special ghost membranes are a new phenomenon, as they appear only when we have two or more parallel universes in the multiverse. The supergravity interaction is defined with the creation of the top in the right-hand side is the topological superstring function of the interaction with insertions of indefinite number of the ghost membranes along the other higher-dimensional supermanifolds. A parent state universe, one of the supermanifold original ones, has ghost membranes along the higher-dimensional interaction just like the baby universe. The parent universe generates baby universes by the membrane pair creation, and baby universes are correlated by conservation of the membrane charges under the process. If the

parent is in anti-state, the ghost membranes are along these lines of the interaction process. This suggests the following interpretation for baby universes with the ghost membranes of the theory. Before the scientists considered baby universes, and in defining the fundamental interaction of the membranes, they had a choice of the boundary conditions at infinity on the membranes. The researchers picked the bundle along the fibers to be flat, the only singularities of the bundle coming from membranes wrapping the higher-dimensional surface and the membranes bound to them. Another feature is presence of a new type of ghost membranes in addition to insertions of membranes that correlate the vector fields in the supermanifold we find yet another set of the ghost membranes that correlate the vector superspace among themselves. It turns out that these correlations also have their origin in a conserved charge: namely the charge of the non-compact membranes wrapping the fibers over the higher-dimensional surface. The large factorization of the black hole function produces topological string partition function on the supermanifold, but with insertions of additional ghost membranes. The ghost membranes generate correlations between the interactions in the different supermembranes. Subsequently, it was shown that the insertions of ghost membranes have a dual closed superstring interpretation. We can in principle pick any choice of boundary conditions at infinity that is consistent with the symmetry of supermanifold we used to compute the interaction which in particular we can pick boundary conditions corresponding to having membranes at wrapping the fibers above points on the spacetime surface. This has exactly the same effect as placing membranes there of charges at large representation would factorize into two independent representations, so this does not introduce any additional correlations between the chiral and the anti-chiral amplitude. However, the charge dependence of this would look like introducing ghost membranes along the fibers in higher-dimensional spacetime wrapped by the membranes where it would look precisely like the insertions of the ghost membranes. From the closed superstring perspective, these ghost membranes also correspond to turning on the supersymmetric deformations of the closed superstring geometry, but these have their origin already in the

quantum deformations of the membranes, namely in turning on charges of the ghost membranes. The explanation of the ghost membrane correlations is then the original baby universe corresponds to infinite membranes along in the higher-dimensional curved superspace with trivial boundary conditions at infinity plus without non-compact membrane charge in the quantum states. Furthermore, for configurations with multiple universes, another set of ghost membranes appears that introduce correlations between the different quantum states. At the next step the new baby universe is created with the units of membrane charge along the supersymmetric interaction, but also carrying some non-compact membrane charge. Their charge is canceled by creating non-compact membranes in the two older universes. The reason the charges appear pairwise conserved is that the ghost membranes connecting one universe with two others are not inserted at coincident points in the superspace, but at different points in the local sector of the hyperspace. Since they are inserted at different points it is natural that the charges appear conserved only pairwise. In general, the amplitudes are independent of the location of the ghost membranes on the higher-dimensional surface with other membranes, as long as these do not coincide. The behaviour of baby universes has been an important ingredient in understanding and quantifying non-critical superstring theory and equivalently the models of higher-dimensional supergravity coupled to matter interactions. The theoretical physicists consider the simplest fundamental state of the parent universe, which can be interpreted as containing just two dressed matter particles, and analyze the emission of baby universes by this state in the lowest order of superstring theory. They find that this emission always occurs with non-conservation of energy of matter in the higher-dimensional parent universe and then proceed to the explicit calculation of the emission rate. Surprisingly, the researchers find that the rate is unsuppressed even for localized distribution of matter in the parent universe, in spite of the long range field this matter produces. The theory conclude by presenting a scenario showing that the non-conservation of bare energy of matter may be consistent both with locality of the emission process and with the presence of long ranged field where in

this scenario, the mass is conserved at the expense of the generation of supergravity fields due to the emission of a baby universe. This gives rise to an extremely interesting possibilities related to the principles of theoretical physics and in particular of quantum cosmology. The most popular approach to the cosmological constant problem is based on the possibility that even if one starts with one topologically connected universe, later on many new baby universes are created from the original one due to quantum tunneling. This idea is very interesting and it may prove to be very productive by the standard lore of the theory of tunneling with the universe production is based on the general approach to quantum cosmology. We develop a stochastic approach to the theory of tunneling with the baby universe formation. This method is applied also to the theory of creation of the baby universe in a laboratory. The theory of baby universes used a simple generalization of the approach to describe the probability of the universe formation in a laboratory at high energy interactions. We could then conceive of a ceaseless process of creation of baby universes that could take place even at the very latest stages of development of the part of the universe that surrounds us. As for the possibility to create the universe in a laboratory, our estimates indicate that one would need a very exceptional high-energy laboratory for quantum gravity. Of course, one may just consider the problem of the universe creation as an interesting theoretical problem to think about in a spare time, but if the universe creation is entirely useless, one may find other interesting problems to solve in the near future. Therefore it seems that the only way to send a message to those who will live in the universe we are planning to create is to encrypt it into the properties of the vacuum state of the new universe connected to the laws of the low-energy physics. Hopefully, one may achieve it by choosing a proper combination of temperature, pressure and external fields, which would lead to creation of the universe in a desirable phase state. The baby universe formation may lead to important modifications of the properties of quantum vacuum state. It is not obvious that the simple physical picture evident in superstring model of infinite number of universes can be extrapolated to the four dimensional case. In superstring theory, there exists a natural causal

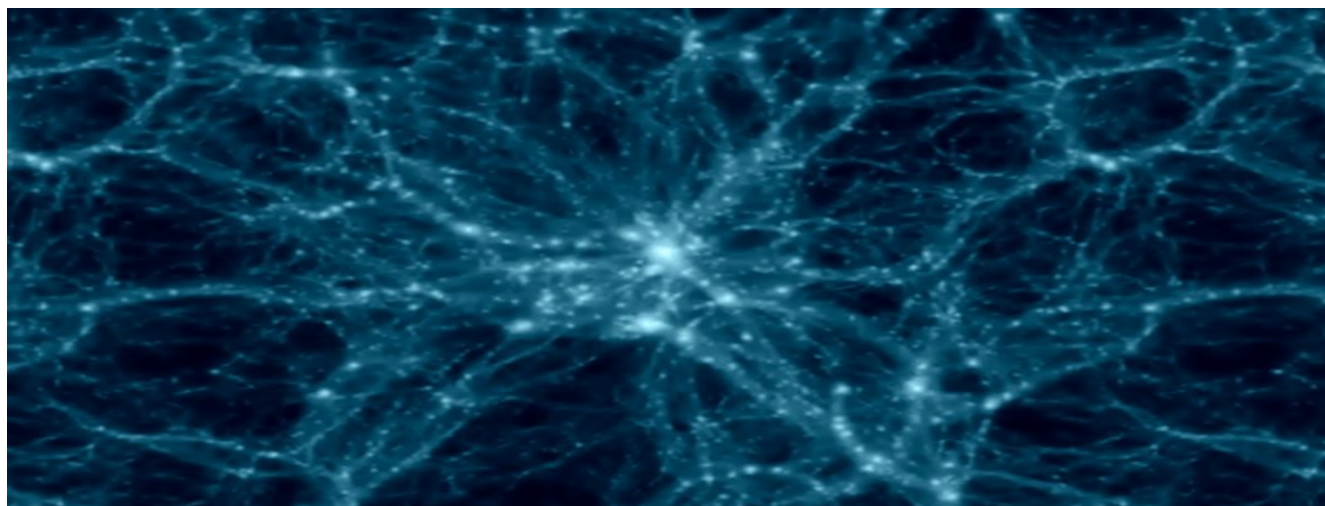
structure of the infinite-dimensional superspace. It is not clear whether such a structure is inherent in the superspace of the higher-dimensional theory. However, it is feasible that the notion of baby universes propagating in superspace, which was crucial for our discussion with some of the known examples of supergravity solutions in diverse dimensions describe the baby universes that branch off and then evolve non-trivially in their intrinsic time. These may be candidates for baby universes travelling in the higher-dimensional superspace. Finally, let us point out that understanding, in the context of the theory, of processes involving baby universes may be of interest for the solutions of the problems in superstring theory, in view of suggestions that baby universes may become important part at the latest stages of the supergravity and superstring theory constructions.

Multiverse Theory and The Membrane Models of Parallel Universes

The universe in which we live can not be just one. In fact, our universe may be just one of an infinite number of universes comprising interacting and building the multiverse. Modern theories of physics give rise to the idea of multiple universes in which there are nearly identical versions of the known universe. Some proponents of the theory say they have found real physical evidence of the existence of the multiverse. Theoretical physicists working on the current model of inflation and how this leads to the island universes say that the evidence of parallel worlds is encoded in our space. The theory of inflation explain some otherwise mysterious features of the big bang, which just had to be admitted in the construction of the theory. He also made a number of testable predictions, which then were spectacularly confirmed by observations. Until now, inflation has become the leading cosmological paradigm. Another key aspect of the new worldview comes from string theory, which is now our best candidate for the fundamental theory of nature exploring and describing all natural interactions. String theory recognizes the huge number of decisions describing membrane universes with different

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physical properties. According to the theory of parallel worlds, the emergence of intelligent design in our universe is the result of fundamental blocks that are collected, combined and manually configured finely life and evolution of our universe, and such processes occur in the billions of other universes living in hyperspace constructing the multiverse.



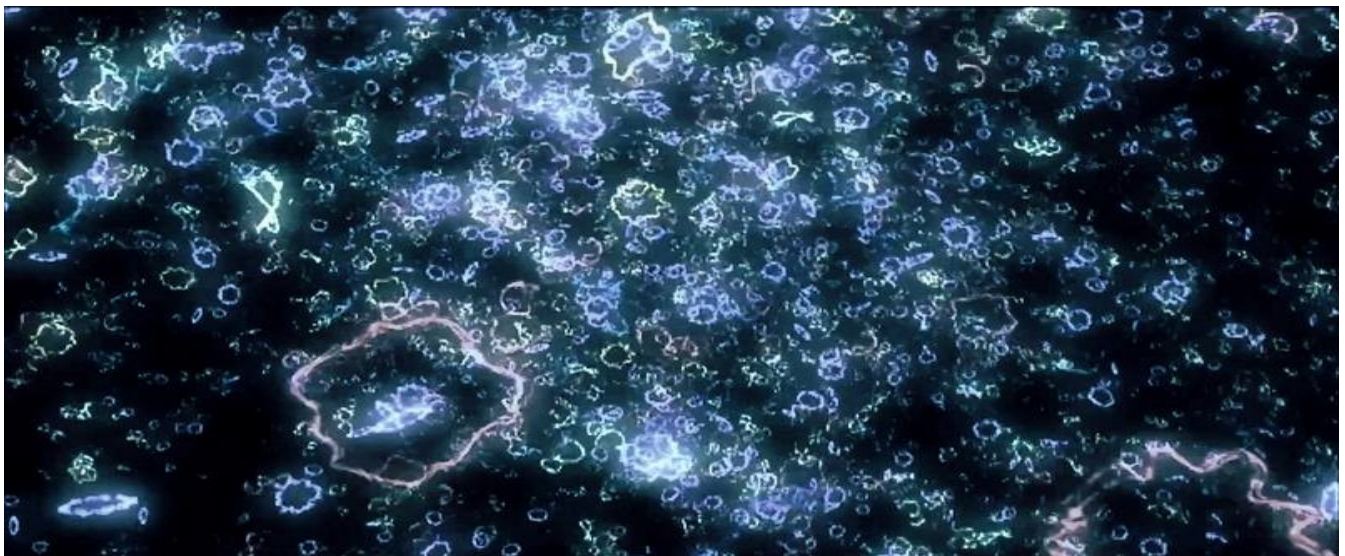
Supergravity Theory and Parallel Universes

Supergravity is a field theory, including through interacting gauge transformations of large numbers of superfields. It is currently the most promising candidate for quantum gravity that combines the principles of supersymmetry and general relativity. The eleventh dimension is the maximum dimension in which we can realize supersymmetry in terms of a ordinary supergravity theory. The theory itself regarded membrane models and allows the existence of parallel universes. The theory of supergravity used and explore an extra dimensions in its theoretical framework. The extra dimensions are spaces in the universe that we can not perceive with our senses. Supergravity characterized universe constructed by eleven space-time dimensions, and includes models characterized by different numbers of dimensions. Supergravity is comparatively beautiful theory that has long existed in the shadow of superstring theory as a unifying universal theory. Supergravity posits that the universe consists of eleven dimensions. For the eleventh dimension is assumed that there coexist various membranes which are models of parallel universes. Supergravity theories in various dimensions nowadays play an

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important role as low-energy effective field theory of superstring and membrane models. M-theory and eleven dimensional supergravity also predict objects called supermembranes. Alternative cosmological theory is connected with the idea that we live in one of these membranes. The requirements of supersymmetric membranes mean that eleven measuring the maximum supersymmetric theory and supergravity is preferred over its lower versions of spacetime dimensions. The supermembranes are hypothetical objects that live and build eleven dimensional theory of supergravity and construct interactions spreading in the supergravity background. In theory constructed successive interactions of membrane and multiplets of matter, representing manifolds of superfields. It has been shown that low energy vibrations of the supermembrane match all superfields in eleven dimensional supergravity measurement. As the vibrations of a supermembrane with endless energy can meet every particle in the universe is possible to interpret that the supermembrane constructed universe, which means everything that exists is one fundamental supermembrane. We exist in this supermembrane including eleven dimensional space-time. Any state of matter in the universe meets the supermembrane and every event in the universe meets and corresponds with the volume of the supermembrane. The importance of the concept of parallel universe can be understood by analyzing the consequences of supergravity theory. This theory can explain the theory of everything, the weak nature of gravity, timing and big bang singularity. All these theories have been one of the greatest unsolved mysteries of physics that concept of parallel universes can explain. The concept of parallel universes explains supergravity, superstring theory, the theory of membrane models and eleven dimensions that are part of our physical reality. All these theories led to the theory of everything, and this theory gives the reason why we exist in this unique universe. String theory says that matter and all the fundamental particles of nature are made by invisible strings that vibrate like strings and this issue is present in ten dimensions. Of these ten dimensions, time is the fourth dimension, and the remaining nine dimensions are spatial dimensions that we humans can not perceive through our senses and sensations. The membrane theory extends this notion and says that

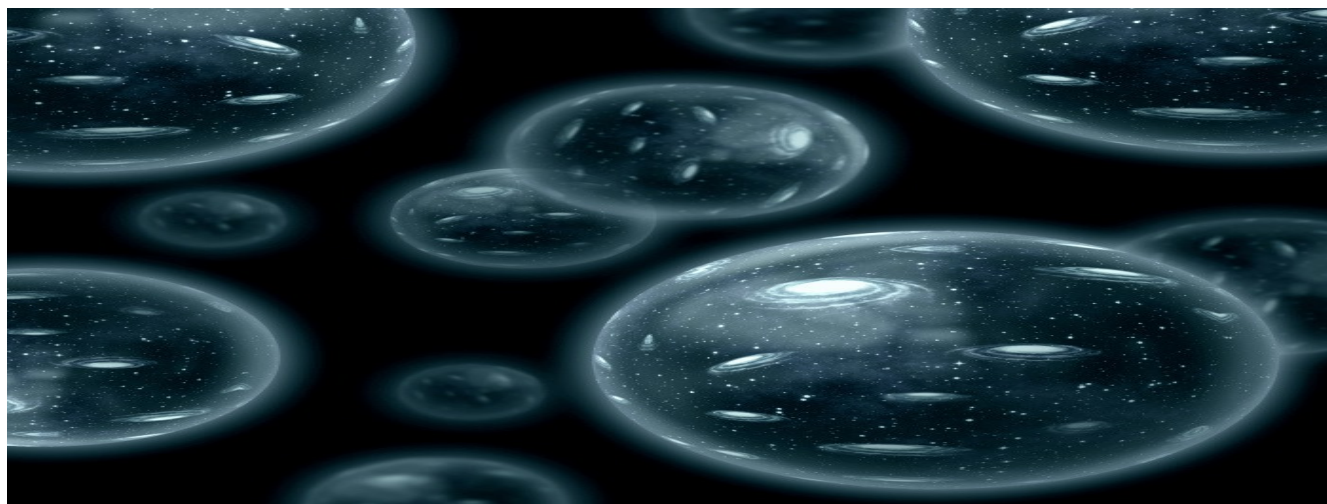
our physical reality consists of eleven dimensions and eleventh dimension is the supergravity. The main superstrings are woven into the membrane and those superstrings are distributed in eleven dimensions. Therefore, the membrane theory or M-theory says that our universe is a membrane. These membranes are parallel to each other and create a series of parallel universes. This theory has several important implications because it explains many mysteries of nature. One of the main examples of such secrets, which could explain its weak nature of gravity. One of the consequences of M-theory suggests that gravity may be leaking from a parallel universe in our membrane or membrane may be that gravity is not an inherent feature of our universe. Parallel universes also defy the general idea that the time begins with the Big Bang. This is the most important dimension than spatial dimensions. Thanks to the modern theory of supergravity which holds gravitino superpartners particles of the gravitational field. M-theory have an infinite number of particles with different masses and also may explain supergravity in eleventh dimension with the help of massless particles. Membranes have shown that self-consistent in eleven dimensions and interact wonderful. There are five ways to reduce the eleven dimensional M-theory to ten dimensions which brought five superstring theories. M-theory deeply combines ten and eleven dimensional physics into a single theory whose low-energy limit is the beautiful and exceptional theory of supergravity.



Superstring Theory and Parallel Universes

Multiverse of a somewhat different kind envisaged in the superstring theory and its higher and elegant extension M-theory. These theories require the presence of ten or eleven spacetime dimensions respectively. The additional six or seven dimensions can either be compacted into a very small scale, or our universe may simply be localized in the dynamic and expanding supermembrane. This opens the possibility that other membranes that could support other universes parallel to our own. This is unlike the universes in quantum multiverse, but these concepts can work simultaneously and elegantly complement. Based on M-theory, which is actually a web of theories, each individual component or theory describes a natural phenomenon within a certain range of the scale. When these scales overlap, different theories agree and everything fits. However, where instruments do not overlap, different theories describe some phenomena that could be involved or disrupt theory tries to explain the multiverse. Given this proposed network of physical theories web of options called M-theory, giving the probability of the existence of other universes with completely different laws of nature. Physicists refer to theoretical subquantum level called string theory to answer anything related to parallel realities. Something beautiful and amazing in itself is the reason that through theoretical classes and tests these theoretical physicists also reached the conclusion that there are parallel universes. String theory says that the basic building blocks of matter, and of all natural forces in the universe exist in the subquantum level up the matter and interact with gravity. Building blocks called superstrings resemble tiny vibrating filaments or flagella strips of fabric that make up the quantum particles of very finely fundamental level. Presumably, the fabric is created by strings and her manner of behavior depends on the vibration of these superstrings. According to superstring theory, composition and distribution of the fundamental interactions are performed in eleven different dimensions and build our entire universe. Like the many-worlds theory, superstring theory shows that there are parallel universes. According to the theory, our universe is like a bubble that exists alongside similar parallel universes. Unlike many-worlds theory,

superstring theory suggests that those universes can come into contact with each other and interact gracefully. String theory says that gravity can flow between these parallel universes and serves as a tool to communicate with them. When these universes interact happens big bang, like the one that created our universe and suggests that the multiverse permanently in place such processes. In the process of development of science, physicists were engaged in reverse engineering the universe - they have studied what they could observe and work back towards smaller and smaller levels of physical world. Thus, physicists try to reach the final theory and the most basic level of knowledge about our world. About dealing with string theory hope will serve as a basis for understanding everything else and will open the door to parallel realities.



Membrane Theory and Brane Cosmology

The time of truth came and went our inquisitive reader into the world of the multiverse where our universe coexist with other membranes, other parallel universes. In fact, there may be an infinite number of membrane universes, each with completely different laws of physics. A key feature of the multiverse is related to physics, called membrane theory or brane cosmology. The membranes enable a whole new range of possibilities in the field of physics of extra dimensions, as the particles with their quantum fields limited to the membrane will interact through various fundamental laws of a parallel universe. Protons, electrons, quarks, all kinds of elementary particles can be glued onto the membrane and fully establish its constitution. By

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removing the superstring in the closed system of the membrane and replacing them with quantized fields located in the curvature of our membrane caused by vibration of the strings of matter, we eliminate the need to rely on the misrepresentation about parallel universes to explain the laws of nature in their unique and finished form. Our universe is an elegant creation, even if included physics and mathematics is turning out to be more complex than we can appeal or an opportunity like this. Simplicity required to admit that the most likely solution is a membrane with gravity, not only a connection between randomly generated supermembranes. Large explosions will happen all the time and so will be born new membranes. If there is an infinite number of universes, then there is an infinite number of times in which two drivers collided to create a big bang just like that created our universe, the exact same physical laws with the same sequence of events from the moment of creation. Multiverse of a somewhat different kind envisaged in the expansion of supergravity, superstring theory, membrane theory, which are elegant components of M-theory. In M-theory our universe and others are created by collisions between membranes in eleven dimensional space-time. Unlike quantum universes in the multiverse, these universes can have completely different laws of physics - everything can be possible and happening processes and events in them which we can not even imagine. Mechanisms to limit the particles and forces caused by some fundamental particles associated with membrane not apply to the gravitational interaction. Gravity, the theory must necessarily exist in the full geometry of space-time included in the membrane. Furthermore, a consistent gravitational theory requires graviton particle that mediates gravity and transports must be connected to a power source, whether that source is limited to membrane or not. Graviton should also be there in the region encompassing the complete geometry of higher dimensions - a region which may include sources of energy in this space. There is a theoretical explanation why the graviton not adhere to each membrane and this is related to string theory. The graviton is associated with a closed string, and only open strings can be anchored and stabilized membrane. Various elementary particles, including superstrings form and stick to the membrane, but

the problem would arise if higher dimensions are invisible to us, at least in conventional ways to verify the theory. In fact, membrane theory allows for the consideration of many different internal spaces in hyperspace, as much as a huge number of different parallel universes exist, interact and swim in the multiverse with its own special set of laws of nature and different physics. In the membrane theory our universe and others are the result of collisions between membranes in eleven dimensional space-time. Unlike quantum universes in the multiverse membrane universes can have completely different laws of physics, it no limit and anything is possible, by the theory can realize all the possibilities of their existence and fundamental nature.

Conclusion

In this popular research report, we have a vision for different theoretical developments on the fundamental membrane theories in the higher dimensional curved spacetime in the current issue of supermanifolds based on the superspaces plus their participation in the hyperspace of the multiverse, where swim, interact and live with extreme fundamental development of these membrane parallel universes. The deep relation between superstring theory and the higher dimensional supergravity provides a basis to conjecture the existence of a theory that similarly completes the supergravity constructions in the various fundamental membrane models. Indeed, it was long expected that fundamental membranes play a role analogous to the one that superstrings play in completing ten and eleven dimensional supergravities. This idea was further stimulated by the discovery that when compactifying eleven dimensional supergravity, wrapped membranes naturally turn into the fundamental superstrings of the types IIA and IIB superstring theories. While it has not actually proved possible to quantise fundamental membranes and derive eleven dimensional supergravity from them, it was argued via duality that there is a consistent theoretical completion of the higher-dimensional supergravities and that stable membranes are an important part of this exceptional theory. The major puzzle in

M-theory has been to understand which, if any, of its degrees of freedom plays the general fundamental role analogous to that of the fundamental superstrings in the fundamental membranes. This is at least partially answered by noticing that when M-theory turns into type IIA superstring theory upon compactifying a spatial dimension, the membrane of M-theory wrapped on this dimension can be identified with the fundamental superstrings. In this sense the membrane appears to be the most fundamental object in M-theory, providing renewed justification for earlier attempts to treat it thus. One must however be very careful about this interpretation because while quantisation and scattering are well-understood perturbatively for the fundamental superstrings, there is no simple analogue for the various membranes in M-theory. The key feature of modern superstring theory is the dynamics of multiple membranes in the hyperspace, which are described by the end points of open and closed superstrings. This description provides a great deal of insight into the worldvolume dynamics of the membranes, which is described by familiar classes of gauge theories augmented by higher-derivative corrections. It should not come as a surprise that the dynamics of multiple membranes is more complex than that of multiple supersymmetric fundamental membranes. In parallel with our limited understanding of everything else about M-theory, relatively little has been known about the degrees of freedom localised on these fundamental membranes. In the last few years, however, considerable progress has been made in understanding the interacting field theory on multiple membranes in M-theory. We note that there have been various attempts to directly define an eleven-dimensional quantum theory of gravity involving exceptional supermembranes. The first, well before the name M-theory was coined, aimed to quantise membranes as one does for superstrings. However this was later found to be fraught with difficulties. A later definition involved reducing the degrees of freedom to those of matrices living on the worldvolume of the membranes in the so-called infinite momentum frame. There is a great deal of literature concerning a single, quantum supermembrane in eleven-dimensional supergravity theory constructions. This review cannot claim to do justice to this topic,

rather we aim to give a review of recent results concerning the internal quantum description of multiple supermembranes in terms of novel highly supersymmetric gauge theories, analogous to the role of Yang-Mills gauge theories on the membranes. Using the results that we have covered as a starting point, the most urgent area of investigation is clearly the dynamics of multiple supermembranes. Here we have surveyed some recent progress in this direction but it is likely that much more will come in the near future. There are of course many other open questions within the vast and beautiful structure of the modern membrane theory, we hope that their resolution and extreme theoretical framework will continue to benefit the beautiful constructions with both fundamental mathematics and theoretical physics. The physics of fundamental supermembranes will develop and reshape the fundamental picture with the advanced knowledge of the world in which we live and will extremely create the necessary idea of our multiverse in the very near future for the mankind.



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