Chance is imperative

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Abstract

In this article it is tried to formulate some theorems to generate a reliable physics system, a physics system like we meet in our familiar universe. It is demanded that the rules that are valid in a universe must be sufficient to generate that universe, the consistency theorem. In the other theorems chance plays an essential role. A number of rules, describing among others chance, are supposed to create the materialization of a universe. Important is the interaction between rules and matter. The possibility to maintain rules without interaction is doubted. The causality in such a universe is weak but present by the rules describing the possibility of realisation of chances. It seems unnecessary to assume consistency in a universe, though some problems rise, the existence of chance can compensate for it. The rules that created our universe hold at least some time after its genesis. We can therefore expect that at least some traces are left from the rules that created our universe. An effort is made the find some examples.

1 Introduction

The astonishment to exist in a world that is around us, is old and universal. The aim to explain that world is probably just as old but looking at the multitude of explanations and the vigour whereby they are questioned it is not easy to find the answers. Much of these explanations are after a long row of steps between of the type "it is just the way it is". That a so little satisfying explanation makes one say; nothing should exist at all, may be intelligible but seems in clear contrast with the experience we have. A second group of explanations supposes that there exist such things as laws of nature which explain the necessity that the known universe takes shape. This thought may be intellectually more attractive, but convincing evidence or even indications that this is the right way to approach the question does hardly exist. The line of thought that I will follow in this article is that I presume that the universe we know exists and exists in such a way that the sequence of "questions why" terminates at some point. It is not meant that it is impossible to ask the next question but that it is unnecessary. It is often doubted, amongst others by Karl Popper, that this is impossible and may be it is, however the assumption that it should be possible leads to a number of demands to our world and may be innumerable other worlds, that should be fulfilled that makes it interesting to examine the assumption. These demands can partly be examined and partly will show us the direction of further research. This article contains five theorems which pinpoint the way the above mentioned might be realized.

2 What is a universe

Looking at a universe or cosmos[i] as a completeness in which laws of nature are valid, it is the word "a" that is special. It suggests the possibility that more universes[ii] may exist, in which other laws of nature are valid. Indeed, there are no indications that the laws of nature we know are obligatory and so unique in character, on the contrary they seem to form despite their high level of abstraction and the generality of principles like symmetry an apparently arbitrary set of rules even when the probably randomized constants that are found in them are not reckoned. Thus it seems sensible to assume that our universe is not unique and that other universes are possible. In that case the question is, what does an other universe look like, are there some demands such a universe should fulfil, and are there classes of universes and questions like that. The construction of imaginary universes with a reconcilability that cannot be rebutted is a useful exercise that might not only give knowledge about what may exist but also about our own universe. Though some assumptions have been made about laws of nature in other universes, the research in this field is still in its infancy. There is however some research about the consequences of slightly different values of constants of nature and the existence of more none curled up dimensions both space like and time like. To stay with a clear line of thoughts I choose some properties for the universes investigated in this article. Because at one hand we have already a conception about a universe and on the other hand it seems impossible to overview all possibility's, I introduce a special type of universe. The question of the possibility of others is left open. Some constraints are made. First I postulate a moderate universe, defined as

D1 A moderate universe is a universe that consists of matter and some rules about the interaction of this matter.

This definition contains at least two notions that are not trivial, being "matter" and "interaction". Two other much used concepts "time" and "space" are missing. On the concern of matter and interaction I assume a strong entanglement. A particle is assumed to be a more or less connected collection of properties which contain information about the interaction with other particles. If some universe shows time or space these time and space are consequences of the kind of interaction that takes place. It seems possible to construct a set of rules that shows no time or space that are looking the way we know them. This is a choice in the controversy that exists between them who suppose that empty space in which events can occur exists and those who suppose that space and time are abstractions used to describe the interaction between particles and has no meaning without these interaction. Next to that I will restrict myself to universes that do have time. A clear example of a different point of view is given by Quintin Smith (1990). Having made some more demands that point to a well known and intuitive direction I will define this as a familiar universe.

D2 A familiar universe is a moderate universe with such laws that it contains time.

In the following I will presume this kind of universe. The idea of time shall not be narrowed too much in advance. Much is thought about time and there is a massive literature on the subject, still it shows to be one of the hardest concepts to tackle, both in physics and philosophy. Failing to describe time unambiguous in this article and still using it seems very vague however it does justice to the fact that despite all scientific research our concept of time is hardly more than intuitive[iii]. For instance the coordinate time is used in many physics descriptions and is well examined, however the existence as a present now in contrast to future and past does not exist in any equation and is for that reason problematic. There are three reasons why I look at universes that do have time. First we seem to live ourselves in such a universe, second these universes are interesting because such a thing as progress seems possible and third here we encounter the question “how did it all get started” . This last question doe not occur in a universe without time because there is no start, the question why that universe exists, if it does, still holds. An interesting question is should a universe be materialized to get in existence or is the mere existence of a set of rules sufficient[iv]. For the reason that the existence of time in a non materialized universe seems impossible to explain even though serious attempts have been made I presume materialization as a premise for a familiar universe.

3 What is a physics system

Before getting more specific it is necessary to give some definitions. The first is that of a physics system.

D3 A physics system is a set of rules describing the kind of matter that exists in a universe and the interactions that occur.

So a physics system can be extraordinary complex even when in analogy to a moderate and a familiar universe a moderate and a familiar physics system are defined. It is even not clear that the number of particles and the number of rules should be finite. Anyhow it seems possible to formulate different physics systems describing different types of universes. Formulated this way it seems that there are hardly any rules that a physics system should fulfil. This however does not hold for at least a familiar physics system. Except that such a system must be able to generate time the question “how did it all get started” must be answered by the rules of this system. It is especially this claim that is the topic of the next chapter. The problem looks like being easy solved; build some running physics system and complete it by adding some rule that describes its origin. The question appears now as being solved but leaves an uneasy feeling, splitting the rules in two independent sets feels highly artificial. It is like changing the rules during the game. Using this receipt you can solve any problem but it smells the flavour of improbability. However its possibility cannot ruled out. There is no reason why rules cannot change in time. On the contrary it is hard to rule out the possibility of change in time in other words to bake timeless rules in matter. The claim of no change is easy formulated but it is hard to find a set of rules that guarantees such time independence. The question will be re-examined later. Some other questions rice. Do we permit the rules to change a little bit? For instance is a constant of nature allowed to have a slightly shifting value, may a rule disappear or on the contrary appear. A next question is, is it necessary that the rules are consistent or are conflicting situations allowed where new rules come ad hoc to existence or even has the consequence that “the system goes down” whatever that means. It is conceivable that a universe with slowly changing rules and not more than rather consistent not only can be imagined but even looks like ours. That is why I will sharpen the definition of a familiar physics system to that of a reliable physics system.

D4 A reliable physics system is a familiar physics system with a set of rules that do not change too much and is rather consistent.

This definition can be seen as a constraint as well as an increase of a familiar physics system. The constraint is trivial but the increase rises from the assumption that it recognises the possibility of change and non consistency. Generally both are supposed to be self-evident forbidden. This definition is an invitation to explore the meaning of "not to much" and "rather consistent" in different circumstances.

4 Theorems

Five theorems form the central part of this article, three in this and two in the next chapter. They are very different in character and probably with a different persuasiveness. The first two are given together because they are strongly related in my attempt to describe the reconcilability of one or more universes.

T1 Materialization theorem

The existence of a set of rules describing a reliable physics system containing the possibility of materialization without further initial conditions may lead to an actual materialization.

T2 Chance theorem

A set of rules as mentioned in T1 always contains events in which conditional chance plays some role.

First some notes on the materialization theorem, this theorem contains some assumptions. It states that materialization exists and even more that is one of the main ingredients of a universe. The reason is not only that materialization seems, though not clearly understood related to the concept of time as stated above but also that when chance is necessary, as stated below, materialization is needed to decide which probability takes place. In a non materialized universe all the possibilities are parallel and at most chance means the chance to be in some universe. It could be opposed that this approach is hard to distinguish from a materialization and so still be reconcilable with the here stated chance theorem. Furthermore the materialization theorem includes that special initial conditions are rejected. The universe is created by the same rules that it contains and that conserve it. By doing so the rules that created the particular universe and which, as being an abstraction, needed no validation are given an exclusive right to rule the universe, at least for some time. This reflection leads to the third theorem.

T3 the consistency theorem

A universe is created by the same rules that it contains.

This probably the most central and most vulnerable assumption in this argumentation. The theorem finds its origin in the wish to formulate a starting point without an act from outside the universe. The latter would shift the question to a former origin. The theorem also makes an never ending chain to an infinite far past unnecessary.[v] The above stated theorems contain the possibility of materialization, may be the most drastic assumption. It is however the logic consequence of what is assumed before. It generates the question is there such a set of rules that might create a materialization. This is an issue of further research. What is interesting on this research is that it not just the eventually outcome yes, no, undecidable, not calculable or some other outcome, but the fact that if there is some outcome it might contain strong evidence about how our universe should look like. The apparent existence of our own universe is an indication that the answer might be yes. This makes this research even more interesting. It might be about us. The interaction between matter and rules is subtle, the rules dictate the possibility of materialization but once a materialization occurred it is the matter that maintains the rules.

The second theorem is the chance theorem. Chance means in the following text nondeterministic. That is when given a condition A is followed either by the condition B or C nothing specifies which of the two will actually take place. More specific the rules might be so formulated that that they contain the possibility that some thing comes to existence without a material history. In the case that something comes from nothing without further conditions it would mean that continuous creating would occur and that when postulating only slowly shifting rules infinity would soon be reached. If a such a rule might exist it would not lead to something that is interesting but just to some unprecedented fullness. If the existence of nothing, that means really nothing not even time or space should lead to something but not too much, chance is left as a restrictive agent. An important consequence of that spontaneous creation is, as a consequence of D4 the just slow shifting of rules, an integrated part of the physics of a universe. The total absence of any form of determinism in the chance definition is so in complete contradiction to the quote of Spinoza "there is no chance just a lack of information". That the existence of chance in the sense that is used here is not common shared is showed by the frequency the statement is quoted. The quest for causal relationships is found in many shapes, from the Moirae, the Greek personifications of destiny, to the mechanical conception of the world. Always it is about an unambiguous linked chain of cause and consequence. In this article it is about real indeterminism also different from the tossing of a coin, or the unpredictability that is described in chaos theory. In 5.1 and 5.2 these items are further discussed. The above does not mean that chance values are independent of any rules or environmental values. It is possible that chance values are bound to the occurrence of some events just as chance can describe the distribution of the realization of exclusive occurrences. It is the combination of the three theorems that describes the taking shape of a universe.

5 Some problems and considerations.

5.1 *Chance*

The first problem is the problem of chance. The problem that rises is that chance can not be described as the chance that that some events occur with some possibility of realization in a given time when the event is the start of a universe. It is indeed the universe itself that gives shape to the concept of time. Though not a problem in its own it means that a glimpse of time independence is conserved while in practise a chance shows a time dependent character. One assumes that when Damocles stays longer under his sword, the chance on a fatal end grows. The question is, is this the correct point of view. First this is a macroscopic and probably deterministic occurrence and second and more fundamental is that the passing of time defines probably and may be even by definition a different condition where the chance on any occurrence is newly defined. [vi] Moreover the existence of time independent chance is a more logical consequence of the above stated then time independent chance is.[vii] The taking place of the occurrence “universe” created and started time just as it created at least the seed of space in those cases where time and space exists. By the fact that the creation of a universe is linked to chance makes it possible that there is a starting point of time. A claim to chance is that it is determined by the set that describes the universe it formed, it is not allowed to define it aside that set. The last would require the meta rules we had excluded to be able to define a start without previous terms. This kind of chance is best described by propensities, also differing between chance single chances and chances that generate a frequency[viii]. For this theory hold the axioms of Kolmogorov. A remark on chance related to time is that chance may generate time. If at a given time t_1 the state A occurs that may lead to B or C without any possibility to decide if it is B or C that occurs and when on moment t_2 B or C occurs than $t_2 > t_1$ [ix]. This means that the realization of occurrence B or C means that t_1 is a part of the past. A last remark is that in the above always a regulated chance is stated, where the rules describe the value of chances. This not trivial but a consequence of the fact that I restricted myself to a description of a reliable physics system.

5.2 *Interaction between rules and matter.*

The second problem is the interaction between rules and matter. The assumption as is shown in the previous, is the existence of rules apart from matter that are the base of the creation of matter. The question rises if once matter is created these rules will remain. In the case of a reliable universe this will, in at least a limited way, be the case for the reason that was stated that those rules should hold in such a universe and therefore should not change to much in a certain time. Probably a universe where this does not hold is possible but the question is, are there universa where such a demand is possible, is more interesting. Next question is why these rules stay there valid. The answer, because this is part of this rules is not satisfying because the universe contains chance and therein the risk of chance. A strong interaction between rules and matter is needed. The way this interaction acts does remarkably well resemble the description of an oak as interaction between organization and matter by Locke[x] . I express it in the following assumptions.

T4 Tuning theorem

In a universe a continuous tuning by interaction between rules and matter is needed to let rules and matter survive unchanged.

T5 The change theorem
Whereas tuning is practically restricted, properties change.

In practise is an example the change in time of constants of physics. Different types of charge may arise or particles may loose the possibility to interact. The possibility to change is enhanced by the complexity of properties a simple property might show sturdier than a more complex one. This differentiation can be imagined for much separated particles or weakly interacting particles. In fact it is much harder to imagine how strong continuous should be to maintain coherence of properties. It is imaginable that particles hardly recognize each other and that cross sections of reactions approach, or even become zero.

5.3 *Consistency*

The third problem is that of consistency. When ever we concern more than one rule the question of consistency rises. Moreover Gödel's second incompleteness theorem[xi] states the impossibility of consistency. That is why I assume that there must be a working set of rules, a set that has sufficient power to create a universe. Considering Gödel it must be doubted that when time unfolds in such a universe consistency proofs to be strong enough to avoid conflicting situations.[xii] It is hard to imagine what could drag the universe to open seas when it runs aground, something that would solve the inconsistency. Mathematical non logic solutions should do this but it is unsure if the in that universe present chance is sufficient to do the trick. At the other hand the existence of inconsistency might be the driving force that pushes chance and we must remind that it is the wish to assume the possibility of a universe that leaded to the theorems we stated. I tried explicit to avoid rules that do not hold in the universe they created. Instead I choose the demand of the consistency theorem that stated of a universe that is at least in its start ruled by the laws that created it. The loss of consistency is not presumed at advance but comes from the speculation that it will be shown impossible to construct a consistent universe or at least one that maintains unchanged rules. As not being a necessary demand it is weakened to such a thing like vulnerable consistency that only can be maintained by enduring interaction and may be even than just local.

6 Meets our universe the theorems.

The description of our universe is far from complete. There are philosophic, mathematical and physical problems in the theoretic realm. Beside that the number of measurements done in our universe is strongly limited. Our lack of knowledge covers the micro cosmos, the universe as a whole and everything in-between. Still some of the rules we find in the universe seem to overlap the theorems stated above.

6.1 Matter

First it is generally believed that matter and rules of nature that govern that matter form our universe. The character of matter is not exhausting examined. This does not only hold for the known particles but next to them there are unverified hypothetical particles and the physical models are incomplete and the possibility of still other particles must be taken in account. Also the rules are not supposed to be complete and even for powerful rules like conservation of energy the possibility that they do not hold under all circumstances is taken serious. So at one hand the knowledge of both matter and rules is limited but at the other hand the existence of matter and rules is hardly challenged and so in accordance with the above stated theorems.

6.2 chance

In the past decennia experiments are developed to distinguish between the different interpretations of quantum mechanics. The interpretation of the EPR paradox with hidden variables seems refuted by such experiments[xiii] . The interpretation that seems to have the best fit to experiments is Niels Bohr's Copenhagen interpretation[xiv]. The "consistent histories" from Griffiths, R. (1984) is in this view an addition to the Copenhagen interpretation. R.P. Feynman's multipath theory also contains chance. Though there are other theories like the multi-worlds theory, chance in our universe is in accordance with the most common interpretations of the quantum mechanics. A strong indication for chance in combination with the existence of just slowly changing rules is what seems to be the first law of our universe: If you have got something, you usually have a lot of it. This holds as well for the smallest known parts of our universe as for the big structures that are unfolded in space. This pinpoints to existence of rules that just slowly change in time. These rules must prescribe the materialization of particles and so will keep on doing that. The huge number of the simple particles seems in accordance with them. The uniformity of distant larger structures seems to prove the maintenance of rules over great volumes and longer periods of time.

6.3 Time

The causality in the proposed view on our universe is weak. This means a strong appeal on the concept time. Time is here related to the existence of more possibilities that can follow some initial condition. The passing of time in our concept means that one of the possibilities occurs and there is no way back once a decision is taken. So time has a direction and maybe it is multi-dimensional, continuous or quantized but not cyclic or even harder to imagine absent. This direction has a deeper source than the arrow of time that comes from the increasing entropy. This is why we made the assumption "familiar universe" is made. Observations do not resist this simple picture however as mentioned before time is a poor understood concept and its description is comprehensible. At most we can say that time seems to exist and shows, by entropy, a direction.

6.4 Changing properties.

Properties in our universe tend to change. The symmetry-break in the four fundamental interactions is one of those changes. If this indeed a consequence of the changing properties as described here an other explanation, like the Higgs field, is unnecessary. There are more things that seem to change. So do properties stay unchanged only if time, charge and parity are all reversed, if just one them is reversed small changes in properties occur. It are this small changes that might be related to the floating of properties. For at least one of the physical constants, the constant of gravity, it is not sure that it has over all distances the same value. This can indicate that it is a changing properties. [xv] A consequence of the changing properties might be the existence of an event horizon. Beyond this horizon properties differ to much to make any interaction possible. The supposed existence of WIMP's [xvi] and other hardly detectable particles seems to indicate that particles have loosing recognisability. At the other hand spectra from far away objects show that on large distances properties are not very different from here, at least at the time of emission. It is just the fine-structure constant α [xvii] that seems to differ over great distances and by the passing of time.

6.5 Methodological criticism

The statements made can be opposed by the argument that I made the suggestion that the theorems are a priori and show to be surprised to find their consequences in our universe though I had some knowledge about that universe in advance. This critic can only be rebutted by the making of some predictions and new discoveries. This seems impossible for the first two theorems, especially considering the chosen definition of the causal independence of the possible universes (section 1). The third and fourth theorems might offer a better grip. Though hard in practice they offer the possibility of experimental research and further information and interpretation from observations from the space.

7 Comparison with existing theories.

Though there is great number of theories, with sometimes very subtle differences between them to understand the genesis of the universe it is clarifying to mention some agreements and differences with some of them [xviii]. The assumption that our universe is not unique is in agreement with many modern theories. Some of them mention the possible forming of universes by quantum fluctuations or the forming from black holes in existing universes. These theories leave the forming of a first universe open, an answer on that question is part of the here formulated theory. The forming of new universes out of an existing one is here left open. Though its possibility seems in agreement with the assumption of floating properties, it is not the quintessence that universes might form this way.
The mathematical universes of Tegmark have in common with the here unfolded theory that they do not start with matter but with a set of rules. However there are also differences. Tegmark does not demand much further constrains for a set of rules. He supposes that every set of rules represents a universe, just as realistic as ours, rules out any chance and supposes that mathematical description makes materialisation impossible. The most important objection against his model is that is has no explanation for the concept of time. Time is just a coordinate like all other. The description of a the arrow of time and the experienced moment as different from past and future stays unsatisfactory.
The Theory of David Lewis is called "*model realism*"[xix] In six doctrines he presumes the existence of more universes with a great resemblance to ours which are not causal interlinked. Also in his theory the existence of time is problematic. He can not combine a starting point in his universes with the existence with an actual moment of time. The concept of "*indexical*" to find an explanation is weak defined and unsatisfactory. The "*many-worlds interpretation*" of Hugh Everett[xx] is in stringent sense not a theory about the genesis of the universe however because this theory rules out chance I want to mention it. The main objection against this theory is once more that it does not generate time. It declares either a starting point as an actual moment.
Totally different in character is the antropic principle as formulated by Dicke, Robert H. and further developed by Barrow, John D and Tipler, Frank J. (1986). The weak antropic principle is in good accordance with this article as is easy to see. The strong antropic principle is not in line with this article, except that it does not recognize chance its starting-point is moreover very different from the here mentioned. The idea does not involve the idea of being self-

generating as is supposed here. The participating antropic principle does in fact not rule out chance nor does it demand it. The character of consciousness is in the universe subtle and hard to understand. An example is the influence of an observer that is still subject of discussion in quantum mechanics. Though at least the question rises if more entities witch have consciousness can both exist in a consciousness driven universe. For universes with non physical explanations and virtual universes the differences are obvious, so I will renunciate the discussion of these points of view.

I tried to formulate some theorems to generate a reliable physics system, a physics system like we meet in to us familiar universe. It is demanded that the rules that are valid in a universe must be sufficient to generate that universe, the consistency theorem. In these theorems chance plays an essential role. A number of rules describing among others chance are supposed to create the materialization of a universe. Important is the interaction between rules and matter. The possibility to maintain rules without interaction is doubted. The causality in a universe is weak but present by the rules describing the possibility of realisation of chances. It seems unnecessary to assume consistency in a universe, though some problems rise, the existence of chance can compensate for it. The rules that created our universe hold at least some time after its genesis. We can therefore expect that at least some traces are left from the rules that created our universe. An effort is made the find some examples.

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[i] Cosmos, Greek means ordered system, in contradiction to chaos. Universe refers to the total of all things and so has different meaning. Despite this difference we will use these words as synonyms.

[ii] If there are more universes it is necessary to use a demarcation criterion In literature the causal principle is often used. I will in accordance with common use call two universes different if there is no causal relation between any event in the one and any event in the other. What are different universes is point of discussion. If any interaction, eventually in the past would be the criterion to reckon two worlds to one universe then the strong hypothetical multiworlds of Everett, the black-hole created worlds and Higgs-bells belong to one universe. More definitions are possible, especially those that find lack of interaction after some moment in time as a sufficient reason to speak of different universes are frequently used. For Higgs-Bells and more common phenomena see for example Achterberg, A (2002).

[iii] Considerations and reflexions on time for example Hawking, S.W. (1988)

[iv] That a universe does not need materialization but can exist by mathematical formulated rules only is argued by Tegmark, M. (2008)

[v] Intervention from outside the universe is probably the oldest assumption for the genesis of the universe. There are numerous narratives of creation with that point of view. However there are deviating assumptions. Epicurus supposed in emulation of Democritus a universe with an endless past. Epicurus chapter 39 "*For if that were possible, anything could be created out of anything, without requiring seeds. And if things which disappear became non-existent, everything in the universe would have surely vanished by now. But the universe has always been as it is now, and always will be, since there is nothing it can change into. Nor is there anything outside the universe which could infiltrate it and produce change.*"

[vi] An example where time independent chance is part of the process is the decay of an instable atomic nucleus. If this is really not time dependent but condition dependent it has some important implications related to time which are hard to survey.

[vii] An example of time independent chance might be the event to win or not to win the lottery. The chance to win is not influenced by a longer storage of your lottery ticket. At the other hand there is the moment of the draw dividing time in for and after this draw. One might say that draw created time with to possible values “for” and “after”.

[viii] There are many publications on the subject. A good review is written by Hájek, A. (2002).

[ix] More complicated cases are possible. Next to mentioned possibility to realize B it also might possible that B rises as consequence from D. In retrospect with reversed time we see that A occurred from B where also D might have occurred from B. You might conclude that this is a decision including that $t_1>t_2$. This would make it possible to reverse the arrow of time. If for at least a number of possible universes there might be conditions D next to B for sufficient conditions to make time reverse possible is not trivial.

[x] Locke, J. (1690) Essay concerning human understanding Book II Chapter XXVII Of Identity and Diversity: 4 Identity of vegetables. *“We must therefore consider wherein an oak differs from a mass of matter, and that seems to me to be in this, that the one is only the cohesion of particles of matter any how united, the other such a disposition of them as constitutes the parts of an oak; and such an organization of those parts as is fit to receive and distribute nourishment, so as to continue and frame the wood, bark, and leaves, &c ……….. it continues to be the same plant as long as it partakes of the same life, though that life be communicated to new particles of matter vitally united to the living plant, in a like continued organization….”*

[xi] Gödel’s incompleteness theorem states that *For any formal effectively generated theory* T *including basic arithmetical truths and also certain truths about formal provability,* T *includes a statement of its own consistency if and only if* T *is inconsistent.* Gödel, K. (1931).

[xii] About the relation between formal systems, calculability, mathematical structures and universes is published by Tegmark. Tegmark, M. (1998) and Tegmark, M. (2008).

[xiii] EPR-paradox, the Einstein, Podolsky and Rosen paradox. The hidden variables are refuted by more advanced versions of Bell’s experiment see as example Walborn S.P., Terra Cuna M.O., Padua S. and Monken C.H., (2002).

[xiv] The quantum mechanical chance can be described in the following way. A particle (like an electron) has two properties A and B. (like impulse, place, spin, colour charge of a quark etc.). Property A can have the value A1 and A2 while B can have a value B1 and B2. The value A1 means the particle is in a state α_1. The other values have similar states. As soon as the value of A, which can only have the values A1 and A2, is measured by a proper method the particle is in a state that is a mixture of β_1 and β_2 . The measuring of the value of B, which surprising only can have values B1 and B2 leads to state that is a mixture of α_1 and α_2 which includes that the value of A is undetermined again. When particles are in mixed states of α_1 and α_2 or β_1 and β_2 it is unpredictable which value A respectively B will have. Just a statistical approach is possible. A and B might have more values then just two but that does not change the story. To precise A and B must have different sets of eigenfunctions, but in most time is the case.

[xv] Gravity is measured on distances of at least a view millimetres. On a large scale the supposed dark matter and negative energy could point to anomalies in the known behaviour of gravity. The range over which the r^{-2} dependence is checked is so very limited.

[xvi] WIMP’s, weakly interacting massive particles. This are hypothetical particles which, because they have very little interaction next to gravity are not yet discovered. These heavy, unknown particles should be responsible for the unexpected large gravity fields on the edge of milky way like constellations.

[xvii] A is the fine-structure constant, a constant without dimension with a value of approximately 1/137. This constant is a combination of the elementary charge, the speed of light, Planck’s constant and the dielectric constant. Recent measurements from Webb et. al. (2001) and others suggest that this fundamental constant of nature had a somewhat different value in space and time. Other measurements do not seem to confirm this observation. A relevant article concerning the state of knowledge about fundamental constants of nature and their time dependence is given by Uzan, J.P. (2003).

[xviii] A good article about different models of the universe is given by Kuhn, R.L. (2007).

[xix] A commented review on the theory on Lewis, K.L. (1986) is given by King, P.J.

[xx] Hugh Everett *Many-worlds interpretation* , an interpretation of the quantum mechanics which supposes that all possibilities that come from one quantum mechanical state are all realized in parallel universes. See Green, B. (2005) or http://en.wikipedia.org/wiki/Many-worlds_interpretation.

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