Our universe may have started by Qubit decoherence

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Abstract

In **quantum computers**, qubits have all their states undefined during calculation and become defined as output ("decoherence"). We study the transition from an uncontrolled, chaotic quantum vacuum ("before") to a clearly interacting "real world". In such a cosmology, the Big Bang singularity is replaced by a condensation event of interacting strings. This triggers a crystallization process. This avoids inflation, not fitting current observations: increasing long-range interactions limit growth and crystal symmetries ensure the same laws of nature and basic symmetries over the whole crystal. Tiny mis-arrangements provide nuclei of superclusters and galaxies and crystal structure allows arrangement of dark (halo regions) and normal matter (galaxy nuclei) for galaxy formation. **Crystals come and go**: an evolutionary cosmology is explored: entropic forces from the quantum soup "outside" of the crystal try to dissolve it. This corresponds to dark energy and leads to a "big rip" in 70 Gyrs. Selection for best growth and condensation events over generations of crystals favors multiple self-organizing processes within the crystal including life or even conscious observers in our universe. Philosophically this theory shows harmony with nature and replaces absurd perspectives of current cosmology. **Independent of cosmology**, we suggest that a "real world" (so our everyday macroscopic world) happens only inside a crystal. "Outside" there is wild quantum foam and superposition of all possibilities. In our crystallized world the vacuum no longer boils but is cooled down by the crystallization event, space-time exists and general relativity holds. Vacuum energy becomes 10^{20} smaller, exactly as observed in our everyday world. We live in a "solid" state, within a crystal, the n quanta which build our world have all their different m states nicely separated. There are only n^m states available for this local "multiverse". The arrow of entropy for each edge of the crystal forms one fate, one world-line or clear development of our world, while layers of the crystal are different system states. **Mathematical leads** from loop quantum gravity (LQG) point to required interactions and potentials. Interaction potentials for strings or loop quanta of any dimension allow a solid, decoherent state of quanta challenging to calculate. However, if we introduce here the heuristic that any type of physical interaction of strings corresponds just to a type of calculation, there is already since 1898 the Hurwitz theorem showing that then only 1D, 2D, 4D and 8D (octonions) allow complex or hypercomplex number calculations. No other hypercomplex numbers and hence dimensions or symmetries are possible to allow calculations without yielding divisions by zero. However, the richest solution allowed by the Hurwitz theorem, octonions, is actually the observed symmetry of our universe, E8. Standard physics such as condensation, crystallization and magnetization but also solid-state physics and quantum computing allow us to show an initial mathematical treatment of our new theory by LQG to describe the cosmological state transformations by equations, and, most importantly, point out routes to parametrization of free parameters looking at testable phenomena, experiments and formulas that describe processes of crystallization, protein folding, magnetization, solid-state physics and quantum computing. This is presented here for LQG, for string theory it would be more elegant but was too demanding to be shown here.

[1]While my previous Opus server preprint "A new cosmology of a crystallization process (decoherence) from the surrounding quantum soup provides heuristics to unify general relativity and quantum physics by solid state physics" (https://doi.org/10.25972/OPUS-23076) deals with the same topics and basic formulas, this new version is improved: clearer in title, better introduction, more stringent in its mathematics and improved discussion of the implications including quantum computing, hints for parametrization and connections to LQG and other current cosmological efforts. This 5th of June 2021 version is again an OPUS preprint, but this will next be edited for Archives https://arxiv.org.

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Introduction: Why Qubit decoherence?

Qubit decoherence and crystallization into defined bits formed our universe

Our universe is surprisingly well ordered and life-friendly. This is the well-known problem of fine-tuning: why is our universe so life-friendly if there are myriads of possibilities that are life-unfriendly? Instead to explain this by complex mathematics we explain this here by looking at normal biology and normal physics. I present here a bioinformatics view on cosmology. This is a different perspective from physicists and allows a fresh look at things. Moreover, this makes all what we claim here in principle testable (looking at normal phenomena) and replaces by this metaphysics and the unexplainable big bang, the start singularity and inflation just by more mundane and normal order creating processes. For me, as bioinformatician, order creation can only come, as for instance during protein folding, if the entropy outside, in the water, increases. This new cosmology is not about creating something from nothing but order creation from a condensation nucleus in the ocean of chaos, and further crystallization. Typical for bioinformatics, this was found at start as heuristic solution looking at protein folding. Looking at biology, life-friendliness does not fall from heaven but can only be the result of a selection process.

In addition, we provide detailed mathematics and a second perspective: our universe may have been created by qubit decoherence. Our universe including all its possibilities are the crystallized or solidified well separated n**m bit states of n qubits, which in the unbound state in the chaotic soup outside would behave as fully coherent and super-positioned n qubits. We thus may be "the result" of a quantum computer calculation. Such a world view may be no surprise to come from a bioinformatician or a computer aficionado, but it takes the old vision that our observable universe is just a calculation (Lloyd, 2002), one decisive step further: our universe and all its possibilities (sometimes called "multiverse") are the *result* of a quantum computing calculation. This is the reason why we are real, and only that allowed the start of our own internal time and hence it is meaningless to ask what was "before".

This is in a nutshell what we want to discuss (**Box I** explains more this introduction). However, to convince may be even a specialist in fundamental physics we have to start step-by-step including solid mathematical hints:

Our cosmology fits well old and recent observations: Cosmology has always to face the test whether it can explain the observed large-scale structure (Dandekar, 1991). Our basic idea presented in this new paper is that usually creation of order from chaos – so creation of something wonderfully ordered such as proteins or snow-flakes – does not happen by "Big Bangs" followed by "inflation" but rather by normal processes such as protein folding or crystallization. The order created inside the protein or inside the crystal implies that outside the entropy increases, so in the water of the living cell the protein exists in, or the solution the crystal grows in and so on. We follow the hypothesis that even for something as big as our observable universe (our "domain") something similar should have happened and no rare, exotic phenomena never heard of before. We replace the "big bang" by an initial condensation event and the "inflation" (Albrecht et al., 2015; Linde 2017; Rosa and Ventura, 2019) by a much less disturbed crystal growth or a magnetization scenario (Weiss domain growth, natural limitation by long-range interactions; Devizorova et al., 2019). This is also in better accordance with observation. The inflation scenario is anyway in serious trouble after there were no perturbations visible 2016 in the BICEP2 experiments (Background Imaging of Cosmic Extragalactic Polarization 2; Chen et al., 2019; Ade et al., 2018). Expert cosmologists such as Steinhardt and Turok propose since long time inflation-less scenarios such as two membranes clanging against each other (Khoury et al., 2004) and such models evolve (Ijjas et al., 2013; Ijjas and Steinhardt, 2016).

Big Bang is replaced by a smooth crystallization process: Crystals can spontaneously start when conditions in the solution are right (**Figure 1**). Thus, we need an explanation how in a boiling quantum soup a condensation nucleus can suddenly form. Surprisingly, this is explained by the Hurwitz theorem (Hurwitz, 1898): If there are any interactions between strings of any number of dimensions, the interactions can only form well-defined for 1D (real numbers), 2D (complex numbers), 4D (quaternions) and 8D (octonions) symmetries. More is mathematically not possible. The richest solution, octonions, corresponds to the E8 symmetry of our world (Wolchover, 2019) and was hence adapted, according to observation. Symmetries, in particular the unit cell, hold always in the whole crystal and exactly this is the reason why our laws of nature apply to the whole crystal without change. This nicely gets rid of inflation to explain why you have always the same laws of nature in our whole domain, our "home crystal". Moreover, the crystal is quite abstract, the unit cell denotes all major conservation laws and the E8 symmetry group of particles. It is hence a very abstract crystal for which the basic foundation can be thought of as a background free (description not requiring time; Rovelli, 2004) quantum spin-loop network.

Further details fit surprisingly well our crystallization scenario: Already salt crystals show that you can have two atom types in the crystal (or more). Our universe relies on dark matter (Ouellet et al., 2019) and normal matter for galaxy formation (Boylan-Kolchin, 2017). Moreover, a crystal is well-ordered but never perfect and so you have the right small fluctuations as condensation starts for super-clusters, galaxies etc. so difficult to accommodate in inflation (and many other expansion scenarios). Moreover, halo regions are governed by dark matter, simply because the crystal formed like this at its crystallization as a condensation seed (**Figure 2**). Similarly, growth of Weiss zones or any crystallization process is self-limiting and leads to a macroscopic but not infinite crystal. This is so much more plausible as the decay of an overheated inflaton (Albrecht et al., 2015) that otherwise leads to inflation forever…

Consideration of evolutionary and selection processes: If you do not have a start singularity or eternal inflation, but rather a condensation nucleus and crystals in general, you can also expect that selection processes impact on different crystals and even different generations of crystals (Konashev, 2019; **Figure 1**). An evolutionary scenario instead of a Big Bang was in particular suggested by Smolin (1996) for black holes as seeds for new universes and selection for a universe having highest number of black holes possible. Black holes are, however, typical end points of star development or for the mass-rich centers of galaxies, they allow not much structure and hence they are very difficult to imagine as start points for new universes unless you assume magical new physics happening inside. Instead, we will stick to our theory of abstract crystals as the start of a new universe. Crystals are observable, natural entities in the form of normal everyday crystals made from sand or proteins. Other properties match again well observation: First of all, crystals do not exist forever, they decay and are formed anew (**Figure 1**). Our universe exists since about 14 billion years. It is philosophically difficult to suggest it exists only since a finite time but should instead exist for ever in future. Moreover, there is dark energy suggesting that something drives out our universe. In my theory this is very clear: proteins decay routinely and are new synthesized in the cell. Now the crystal-universe is in contact with the chaotic string soup /chaotic quantum spin foam "outside" and this interferes constantly with the compact structure of the crystal and ultimately tears it apart – in my theory this is the source of "dark energy" (Huterer and

Shafer, 2018). What is more: as the force is “outside” our domain, this force tugs constantly and all around the crystal. Hence, you may have the behavior of a scalar field currently assumed for dark energy though this is really only shown for the Higgs boson. With time, the tug on the aging crystal increases and it dissolves (**Figure 1**). At least we observe also an increase of dark energy over time.

Furthermore, you only can derive again an energy-rich universe at the life-time start of the crystal (as our observable universe for sure did start from a very high energy state) if these crystals are reborn from time to time. If conditions are favorable choosing a certain way of two strings / quantum-loops to interact, so that they stabilize themselves, then this interaction pair will attract more strings from the chaotic string soup (or loop quantums from the spin-foam). These form a condensation point of crystallization (a crystallization seed). This can happen from time to time anywhere in the string-soup, replacing the older crystals removed and torn apart by dark energy.

If you assume such a life-cycle of a universe, then comparison with biology tells you that an evolution can easily result: the dominant species will be particular stable crystals and those which loose on their edges most new and stable condensation seeds. This was pioneered by the idea that a universe with more black holes has more offspring (Smolin, 1997). However, the crystal concept shows intuitively how selection for a large and very stable crystal with lots of offspring is happening. Moreover, also normal crystals can shed new condensation nuclei at their surface. This explains why our universe is then so special and fine-tuned: it is favoring lots of self-organizing processes including life, as the crystal and offspring basis for our universe is a high degree of self-organization to give rise to new offspring. Physics theoreticians know so much about the fundamental, all permeating basic concept of time (Smolin, 2013) to understand that this is beyond our everyday concept of “time”. What you have in the end (“background free”, looking without the concept of time) is a stable population of high ordered universes such as our one, another population of much less ordered and unstable crystals (maybe with less or more dimensions as in our universe etc.) and the big ocean of string soup / chaotic spin-foam in which everything making up the crystals (or “universes”) is swimming.

Justification from quantum theory: The mystery of decoherence. This establishes our theory independent from cosmological arguments. The crystallization process means that everything becomes “particle-like”, a clear condensed 4D crystal with a very defined trajectory in time and space for all involved particles (**Figure 3**). We have here only one real world. The other trajectories are possible, but happen in other worlds (Tegmark, 2007) parallel to ours, that crystallized probably at the same time from the same seed and are forming other crystal layers within the same crystal. This crystallization decoherence makes sure that in macroscopic observations we have time just as a normal dimension (Smolin, 2013). The multi-world alternatives and the ever more possibilities as entropy increases are only visible for microscopic dimensions and for the small observation regions where coherence and entanglement is possible (**Figure 4**). This poses also a limit for quantum computers, probably they can only be built up in a modular way, individual units have very small boundaries and become too soon decoherent if their size increases (Xin et al., 2019). Probably the Bohm guiding fields (Englert et al., 1992) are correct for our world, our clear crystallized 4D trajectory (Mahler et al., 2016). The crystal is very solid and a break-down of layers will only happen by extensive use of force (on the order of the formation energy).

However, for small actions (smaller then Planck´s quantum h) the crystal is soft and you can sample and reach "next" or even "over-next" crystal layers and for minimalistic time-scales reach really far out. However, as this is only reaching-out and not changing the specific trajectories of your own crystal layer, we think according to this theory, you always stay in a defined future and trajectory.

Related cosmological theories: In the following we develop only first mathematical steps for our theory. Hence, this preprint is in this respect close to Edgar Alan Poe´s "Eureka" (1848). He used poetic heuristics with his new physics that presaged modern science even anticipating black holes and the big crunch theory (Smooth and Davidson, 1994). Unfortunately, some of his assumed laws were completely wrong, but he was the first to spot the expansion of the universe, even before Edwin Hubble and Lemaitre by his poetic vision. Similarly, the mathematical proof and tests of mathematical consistency for this crystallization theory of the universe is not attempted here in this preprint, we give however a number of valuable hints and suggestions which mathematical problems have to be faced and which theorems provide hints and help.

We should also mention (i) the paper by Chuang et al. (1991) in which defect dynamics of liquid crystals were used as toy model for the standard cosmology (so in this sense the opposite direction of this paper, confirmation of standard cosmology was the aim of Chuang et al., 1991) and (ii) the work by Smolin (1997) where fecund universes depend for reproduction on the number of black holes created. This introduces the basic concept of an evolutionary scenario albeit completely different from the scenario presented here as relying on black holes as baby universe, in my view a much less plausible theory then the crystal life cycle proposed here.

In general, there are a number of **evolutionary cosmologies** around which are only briefly mentioned as they follow completely different theory paths. It is of course easy to describe that there is evolution inside our universe (e.g. Longair, 1996) but to take it to whole universes and generations of universes allows a wide-range of theories from considering a "breathing universe" from the standard model but if the critical density stays high enough so that collapse follows after expansion of our universe to a maximum radius and then this happens in many cycles. In such theoretical frameworks you often find increasing entropy as cycles progress. However, alternative theories have evolutionary elements of succession of universes combined with esoteric ingredients. This is not followed here. Finally, **emergent gravity** (Kleinert, 1987; Brian and Van Raamsdonk, 2014; Eunseok et al., 2018) is a framework which shares some features with our approach. In particular, Sakharov (1967) started ("induced gravity") with an arbitrary background pseudo-Riemannian manifold and introduced quantum fields (matter) on it. He did not introduce any gravitational dynamics explicitly. However, emergent phenomena from condensed matter systems are considered here, too, for instance that crystal defects give curvature and torsion to a spacetime. Similarly, general relativity arises as an emergent property of matter fields and is not put in by hand. Erik Peter Verlinde introduced the concept of entropic gravity (Verlinde, 2017) arising from entropic forces. In his theory, gravity exists because of a difference in concentration of information in the empty space between two masses and its surroundings. However, this class of models leads to huge cosmological constants. My approach is clearly different for instance in how crystal defects are treated and it is also more "top-down", starting with the formation of a very abstract crystal (but, similar to Verlinde, 2017, emerging from a quantum soup and considering entropy, too) and then considering its symmetry properties directly as local (within the crystal) emerging "laws of nature" and so on. Nevertheless, from the string interaction field (only 4 solutions possible according to Hurwitz theorem) there (i) is the

emergence of the crystal with strong interaction force and crystallization with growth and solidification (ii) symmetry breaking and cooling down leads then to the emergence of the four basic forces including strong and weak nuclear force, electromagnetism and – as in other symmetry breaking scenarios - gravity.

Course of results presented in this paper: The results chapters explain first the heuristics used in detail: how the ideas from the introduction may form a unification bridge for general relativity and quantum physics (section 1), we give cosmological arguments for the theory (section 2), introduce an evolutionary cosmology to explain fine-tuning (section 3) and provide in section 4 (heuristics from biology) first formulas for the mathematical foundation of our theory. Building on this, section 5 discusses physical implications and shows that the postulates derived are independent from each other and give heuristic hints to search for a grand unified theory. Finally, section 6 delineates the mathematical tasks ahead to derive from the heuristic assumptions made a quantitative theory and work on the involved formulas to derive consistency checks and quantitative predictions – there is a long, windy road ahead and the mathematics clearly challenging. Nevertheless, the fundamental results within reach hopefully stimulate more powerful scientists to probe and calculate here further.

Results: How to unify general relativity with quantum physics by solid state physics

Clearly, the grand unified theory explaining how both major theories fit together would be a scientific breakthrough. We present here some corner-stones and concepts for such a major advance (**Table 1**) in the hope that the suggestions are sufficiently popular that the community will come-up with suitable mathematics (the major work and ingredient for the breakthrough and not done here). We also make clear which type of mathematics is necessary to get really testable predictions, but depend here on the enthusiasm of the community to follow this up further.

1. Solid state physics as a bridge between general relativity and quantum physics

Well, a first example is that the AdS/CFT correspondence appears also in solid state physics https://arxiv.org/pdf/1612.07324.pdf (a nice review by Sean A Hartnoll, field theoretician, physicist Andrew Lucas und Subir Sachdev solid state physicist). For some insights from this AdS/CFT correspondence on our theory, see the section "discussion of the mathematical aspects" below. The huge advantage to have solid state physics involved is that theoretical statements become testable, for instance in crystals (Kawasaki and Tanaka, 2010; old cosmological example: Chuang et al., 1991).

My vision is much easier to understand (**Fig. 1 – Fig. 4**):

I imagine that the real world is a consolidated state, a solid state and that the quantum wave function (e.g. solution of the Schrödinger equation) is an unconsolidated, liquid state. My suggestion is that reality, consolidated state happen in a crystal, and here there is a macroscopic clear and real world whereas the wave-like, undefined chaos is everything outside of the crystal. Only in the crystal hence everything is as in everyday experience, whereas the quantum chaos is outside of the universe.
In other words, I imagine that we live in a crystal-like world where everything did "freeze" almost completely. That is the reason why general relativity holds, in particular for large distances (macroscopic dimensions). In microscopic dimensions (below the Planck quantum h) everything is still fuzzy, as the crystal is not completely frozen, for small distances it is still liquid. However, the multiple worlds of the Everett model are transformed in this vision to the flat layers of the crystal, each macroscopically different trajectory is one further layer of the crystal (closeness according to similarity), and the slices thickness correspond to the microscopic fuzziness of quantum states all compatible with the same macroscopic trajectory.

New perspective: A solid, decoherent, real world from an ocean of chaotic loop quantums

My crystal paradigm starts with our solid, decoherent, real world (our whole universe including all its quantum states, often called "multiverse", see below), envisioned as a crystal (no inflation but crystal structure guarantees to have the same laws everywhere). Importantly, there is an "outside": the crystal, our world, is floating in the quantum chaos ocean where all superpositions exist and the vacuum boils wildly. So again, this theory starts not from nothing but from the wild quantum ocean. My pictures (Fig. 1 to 4) allow to have a fresh, inspiring look at the relationship of the big theories to each other:
Quantum mechanics (QM) has in its classical formulation a non-dynamical space time incompatible with general relativity (GR). However, GR considers spacetime wobbling

(curvature, gravitation fields, etc.) but there is no easy quantization possible. How can both theories be reconciled?
Well, the solution from the fresh perspective is easy (Fig. 4): In our world GR holds well, we have time and space and can determine the curvature of this space-time as the crystallization makes sure that we have space and time and reality ("brick" of frozen-out qubits with clearly defined bits in the center of Fig. 4). In contrast, QM definitely exists outside the crystal as a wild, boiling ocean (bubbling background of Fig. 4): However, QM lives also inside the "brick" on quantum scales: the qubits became bound, nicely ordered, magnetized, decoherent, frozen out states to form the "brick", yet, there is little liquidity left just below h dash, only below Planck´s quantum still everything goes *wild*.

Similarly, one can have a fresh look at the two contender theories to bridge GR and QM. Loop quantum gravity (LQG) is a general-relativistic quantum field theory, so has then properly transported GR also to QM. The important ingredient of LQG is that it is background independent, instead of time and space we have a loop quantum spin network. The surprise from my fresh look at such unifying theories is that LQG works at both places, inside the crystal and outside in the boiling soup: This is so as the loop quantum spin network can easily be transferred to any number of dimensions, though there is good reason (see math section) that only crystals with basic symmetries of 1D, 2D, 4D or 8D are stable. Hence, the stable part of LQG described worlds are the crystals, but the unstable soup is also covered by a very wild spin-loop network. Even the interaction field necessary to force this wild boiling liquid soup into an orderly shaped crystal can be properly described by LQG both for attractive and stabilizing repulsive forces. For a more orderly phrased mathematical glimpse see section 6, mathematical part.

Now would string theory may be even better explain our universe? Well, it starts from the hypothesis that elementary objects are extended, rather then particle-like. This yields a rich theory including fermions, Yang-Mill fields and gravitons and it may even be free of ultraviolet divergences. However, it has a gigantic baggage of additional physics such as supersymmetry, extra dimensions, an infinite number of fields with arbitrary masses and spins. Maybe the largest drawback are the extremely high degrees of freedom (on the order of 10^{600}) which make it impossible to falsify it, reaching here almost metaphysics though starting from pure math (so in this sense: never wrong, really consistent, fundamental truth).
Now, the fascinating point is that my fresh look provides immediately a solution: while **LQG** readily is applied to the crystal as it directly starts from **GR** and hence a real, frozen out state which includes then quantization, string theory with all the above features and the many version of fields etc. starts from the quantum soup. This is also correct in that sense that the "ocean" of the "outside soup" is of course dominating while the crystals inside it are much smaller. However, from this perspective it is also immediately clear what is missing: Instead of being easy able to solve the bound state necessary for a condensation nucleus of a "real" world, a frozen-out crystal applying **LQG**, this is a really challenging task for a non-expert in string theory with its demanding mathematical structure. However, my hope is that much better string theoreticians then I can ever be will take up this challenge, as of course both perspectives have their right: you can start from the crystal and use the spin-loop-network formalism being background free and hence readily transferred also to the "wild soup" (**LQG** perspective), the "outside", or:
you start from the wild soup and fix the many parameters such that you derive our world (in my opinion the string theory challenge). However, I have an important hint to tell: Only certain sets of parameters allow strings of any dimension to interact and this hint only needs to be implemented, so is my prediction, and then the parameters of string theory are nicely fixed because our world is real, decoherent and hence a bound state of the quantum soup.

As a side-line, also more vague quantum theories loose unnecessary mystery: For instance, "it-from-bit" or stressing the process of observation and hence information as necessary to create our real world, coining the term "Participatory Anthropic Principle" (Wheeler, 1990): Wheeler is right in that sense that the whole real universe (e.g. our universe or domain of observation) has to be in a state of decoherence to be real. Now, instead of postulating the extreme idea of Wheeler and followers until today that the observation event does such an extreme creation event, we here simply observe that qubits remain undefined and come only into a defined, decoherent existence when they crystallize (e.g. Fig. 1). A related error (in my opinion, straightened out in the following) is to mistake the decoherence of qubits into the defined bits and quantum states of our world as evidence for a continuous splitting of our world into new worlds with every decision event (the Everett-like multi-verse). This is simply wrong (see Fig. 4 and the next paragraph).

Bell´s phenomenon, so that two entangled particles become both defined, even if light years apart, just by the measurement process on one particle, is in this theory easy explained: If the entangled particles share one wave function, their states are of course coupled (standard formulation of Bell´s phenomenon). The measurement process in our world, even if made only on one particle (in this theory our world is just one slice of the crystal) freezes out the free wave function to a bound, defined state and hence brings out the two particles in one defined configuration (typical one particle has the opposite spin to the other, details depend on the measurement set-up). The other solution for the measurement is however only observed in another slice of the crystal (see Figure 4). Exact probabilities how many slices measure which result depend on the quantum wave function according to standard quantum physics. All transition probabilities are considered and each quantum state as this is allowed and given by the n qubits forming the whole crystal and all slices of it (see next section).

World creation means that quantum states become separated and are no longer superposed, hence are defined. It is important to realize that quanta are usually undefined, hence a number m of quanta will each be in their accessible n states (for simplicity I assume here that the same number of states is accessible for each quantum). So the wave function for these will be a superposition of n**m states. My central claim is that "normally" everything is in this undefined superposition state and that only "crystallization", "freezing-out" will allow clear separation of this superposition. This creates then a real world. In a real world you have an assembly of m quanta (if and only if the strings interact, and interaction is limited to the four Hurwitz solutions for operations between numbers) and if they can have for simplicity only two states (up and down) you have low entropy states (all up) and high entropy states (half of the up and down). So just by freezing out all possible states for the world are separated and created. Moreover, the time within the world ("within the crystal") follows the arrow of entropy and each minor change goes into the direction of higher entropy over time, while different world trajectories are separated by layers within the crystal. This is a very economic way of understanding why there is no multiverse in the Everett sense (a split for any decision etc.) but rather the normal high number of accessible states for m quanta which is n^m just freezes out. There is one world, but now it is no longer a "liquid", "undefined" quantum foam but clear, defined "decoherent" quantum trajectories.

1. Emergent time at the edges of the crystal: one crystal, a rather economic multiverse

The emergent time and different fate trajectories freeze out at the same time: For example, we have 32 states for 5 qubits, the entropy of the different states is sketched in Figure 4 and gives early (high energy) and late (high entropy) states. Edges (transitions) between the states are possible as the crystal is not completely frozen out. The latter would yield completely separated states without any connection. This would kill the original, free wave function of the quantum soup around completely and, according to this theory require infinite energy. However, we know that below h dash in our world (and any of the typical crystals) it is still liquid and that enables quantum transitions. Hence, all connections are still there and emergent time is possible (compare to emergent gravity concepts such as Verlinde (2017): According to this theory, only due to the remaining liquidity of the crystal our internal time and, in fact, all different world trajectories are possible: The remaining parallelism and completeness of the wave function, which is without limits and for any size of an action (energy * time) outside in the soup. So, with this inbuilt remaining liquidity inside the crystal, for n qubits which each has m states we have a total of n**m different configurations ("moments", so to speak) and there are (n**m)! possibilities how they can be connected (different emergent time and corresponding trajectories, "fates"), all this is also for sure there in this theory as the wave function where it is unbound has still all possibilities in coherence and a completely frozen out state is not possible and only this would kill the inbuilt parallelism.
From this large number of trajectories, the majority goes entropic backward and is hence extremely low in probability ("thin" trajectory), and in the right direction of the arrow of entropy there are far less (Figure 4; in the example with the 5 qubits there are 32 states and hence 32! possibilities, however, in the right direction of entropy there are only 1*5*10 = 50 possibilities plus the mirror configurations, so 100, a very small number of different fates in comparison. This solves rather economically the problem of Everett multiverses: we have only few qubits and there inbuild parallelism, even in solid state, allows then due to the remaining liquidity emergent time and a surprisingly low number of time trajectories with correct direction ("future"). This emergent time is only internal: it is there as long as the crystal is there, in contrast to the eternal outside soup, which is background free (no time there, only a quantum spin loop foam according to LQG, QLC).

2. Singularity at start is replaced by a testable crystallization process

My home field is biology and with this in mind, the current cosmological theories seem to be completely wrong, as they assume an explosion from nothing, and even an inflaton starting particle and inflation for the very first moments of the universe.
Instead, in biology proteins form with loss of entropy and ever higher order, for instance reaching a highly sophisticated enzyme or receptor structure as they increase entropy in the solvent around. It is far more reasonable (as observed million times in nature) to assume a similar process at the start of the universe then a "big bang" from nothing.
So here my idea from solid-state physics is that we have NOT creation from nothing but rather we have an ocean already present (a boiling and wild string soup, an "active vacuum") and then after an initial strong and suitable interaction between strings (**postulate 1**) you have a condensation nucleus. Hence, I believe not in creation from nothing but rather in
As seen numerous times in magnetization this then induces in the string soup magnetization and more interaction between strings and as a growing magnetization zone ("Weiss zone") the crystal grows from the condensation nucleus (**postulate 2**).
As with real crystals or with real magnets this growth becomes also not infinite (it is amazing that Linde (2017) could convince so many cosmologists with this never-observed concept of eternal inflation), rather the stronger and stronger growing long-range forces limit the growth of magnetization or crystal growth. In the whole crystal you have the same order and hence

the same symmetries which translate for the human observer to the same laws of nature in the whole crystal. There is no bizarre inflaton and inflation process necessary (never observed before and latest observations of the bicep/2 experiments even rule this out), but crystallization of a rather abstract crystal explains the mystery.

3. Selection for optimal crystal growth and seed generation may explain fine tuning of the universe for self-organizing processes including life

Why are all constants of nature (in our observable universe) so fine-tuned to allow life (including stable stars, stable nucleons, planetary orbits, billions of years radiation from nuclear fusion etc.)? This well known cosmological problem of fine-tuning is currently not convincingly explained in cosmology. For instance, according to the text-book scenario of big-bang and subsequent inflation, this can only be explained as one of myriad possibilities, so a really strange, freak-like accident allowing life and an intelligent observer (Hawking and Hertog, 2006; Koonin, 2007). Though the anthropocentric principle (Barrow and Tipler, 1986) explains at least why nowhere else (in none of the chaotic universes life can exist) somebody can wonder about his fate, to be an extremely strange accident points to a rather low explanatory value of that theory.
Instead, in biology the explanation for wonderful fine-tuned structures is always evolution and selection processes leading to such well-adapted and hence well ordered structures. For instance, the sophisticated enzyme structures did not happen from an explosion but rather by evolution. Similarly, for non-alive structures, again self-ordering processes make sure that high order and fine-tuned adaptation is achieved, e.g. in sand dunes or in snow-flakes.
Thus, to discuss more such processes in cosmology is currently clearly missing and the result of this gap is that life seems to be a miracle or a not-considered phenomenon in current cosmology (e.g. Hawking and Hertog, 2006 as well as Koonin, 2007 both press the point that in a fantastic large multiverse (e.g. all the 10**600 parameter variants of String theory) even the strangest phenomenon including life and a life-friendly universe are possible).

In current standard-model cosmology any type of evolution is simply not build-in, however, if you start with a crystallization process and a crystal, it is possible to invoke evolution, in particular if you have several generations:
Then clearly, subsequent generations of crystals will be selected to be more and more efficient to make sure that the next generation of crystals exist. In my personal opinion it is hence with overwhelming probability that you should consider such evolutionary processes, at the very least selection processes (postulate 3) when you want to understand why our universe is so life-friendly and optimally fine-tuned for this.

4. Crystallization and protein folding happen naturally and by entropy generation in the solvent

Formula abbreviation strategy: In the following, building on the three postulates my theory is fully explained including up-to-date physics references. Natural phenomena from biology and biophysics shows how complex, ordered structures form usually. This happens without miracles or “Big Bangs” but nevertheless the laws of thermodynamics and all the rest of physics has to be obtained. This aspect, cosmology should orient itself towards normal phenomena which are observed in nature (e.g. in the lab) and not towards never observed strange events (“singularity”, “Big Bang”, “inflation”; see also own 2019 preprint https://opus.bibliothek.uni-wuerzburg.de/frontdoor/index/index/docId/18394 , but without striving to present more solid mathematics).

Moreover, natural phenomena also show that you never have “something” from nothing. This theory does not attempt to achieve this, but just as in protein folding or crystallization that there is a liquid before there: water in protein folding, so that order is created inside the protein but more entropy in the water outside of the protein or the well saturated solution from which a crystal forms, best from condensation nuclei. Hence, outside of our domain or “before” (we have no real time outside of our crystal, see detailed treatment below), we assume a boiling ocean, the wild vacuum or quantum soup as start from which, given correct interactions, something can form that yields ultimately our world.

I mentioned in the introduction that the formulas are challenging to write in a compact way and even more so their derivation. So here I introduce a very concise shorthand:
Red roman numbers in the following denote classical formulas and I give then the paper where you find the corresponding formula. Hence, the first formula example describes the entropy considerations in protein folding just by a roman letter one, i.e. **(I).**
It represents then the development given by Ghosh and Dill in their 2009 PNAS paper, starting with

$S_D = Nk \ln z,$

which is formula [1] in their paper and considers for an N-mer, the approximate chain entropy of the denatured state S_D according to this formula. The authors start with the chain entropy: “For a chain having N monomers, the number of conformers in the denatured state will be approximately zN, where z is the number of rotational isomers around a given backbone lattice bond.” Sections treating mathematics are sometimes given in blue in the following, to again indicate that they are currently only an abbreviated overview, exact calculations will require a lot of time.

Comparing cosmology to protein folding and crystal growth: Particular instructive are protein folding and crystal growth:
Protein folding shows that usually order and function is not mysteriously created by a “Big Bang” but rather the higher order in the protein is physically “allowed” as the disorder in the water around increases.

Typical protein folding **formulas to describe compact protein and rising entropy in the water** around it **(I)** are given by Dill´s seminal work on theoretical protein folding (e.g. Ghosh and Dill (2009)).

The itinerary to go.

The main work is to derive formulas from known cosmology, look at the physical normal formulas for protein folding, crystallization and solid-state physics and estimate from these the properties of the abstract “crystal” we live in and compare them with observation.

Normal observable physical phenomena, repeatable and testable are given by roman numbering and additional derivations by small letters, cosmological formulas***** are given by an asterisk, double ****** denote the particular challenging nD case where strings of any dimension have to be considered (unfortunately no string theory treatment is presently possible for me, I gave hence the quantum-spin-loop formulation which is no full substitute).

First typical protein folding formulas to describe compact protein and rising entropy in the water around it are given by Dill (e.g Gosh and Dill, 2009): **(I)**

Formulas to form a condensation nucleus in a crystal **(II).**
These have now be compared to the N-Dimensional String Interaction potential which has, according to the Hurwitz Theorem (**IIa**), only the possibility if they interact, to interact as real numbers, complex numbers, quaternions or octonions
String Interaction is given according to the fomulas by Asthekar et al. (2006): **(II*).**
This includes estimates for the repulsive forces **(IIa*) .** However, to find out how the quantum soup without any world, so the real quantum vacuum behaves, we have to modify both formulas to allow any number of dimensions **(II**)** and **(IIa**).**

Formulas for growth of such crystals **(iii)** and their dissolution **(IIIa)** but this now taken from the normal physics to cosmology using a string theory or loop quantum formalism **(IIIa*)**. A help for doing this correctly and choose the proper parameters required is that the observable ("crystal decay") should correspond to our dark energy "force" and should have increased the last 7 billion years **(IIIb*)**.

Formulas for unit cell properties in a crystal **(iv)**

Formulas on unevenness in the crystal (displacements) **(v)** and now transform this to our string-theory or quantum-loop-like description of our universe as a crystal **(v*)**.

Formulas for normal crystal breakage rate **(vI)**, however, the formula **(vi*)** becomes then already rather challenging as it has to consider **(II**)** and **(IIa**)** (n-dimensional string interactions and repulsive forces).

Formulas for growth of a magnetic zone (**VII)** and for crystal growth **(iii)** but now considering limit of crystal growth over certain sizes by long-range interactions **(VIIa)**. This now has, however, taken to cosmology, which means that you start again with the n-dimensional string interactions and repulsive forces **(II**)** and **(IIa**)**, derive from this the magnetization-like growth of the crystal as soon as the first condensation nucleus did form (**VII*)** and its limitation by long range interactions **(Viia*)**.

Quite interesting and exciting, the crystallization paradigm solves a lot of fundamental questions by showing that the question is wrongly asked and hence the search for formulas explaining this is futile: In my theory, the basic symmetries and laws of nature inside of the crystal are ensured not by inflation but by crystal symmetry properties. Hence,
(i) Real crystals are never perfect: hence we have small errors and unevenness as nuclei for future superclusters and galaxies without any intricate search for formulas and reasons how this can happen after inflationary explosion (wrong question, this never happened).
(ii) Similarly, the conundrum why matter dominates anti-matter is easily solved: The symmetries in our crystal are such, that we have matter. There may be crystals which have the mirror image of this symmetry and anti-matter, but these are other crystals, this is not our crystal. No search for formulas explaining why after a wild and out-of-the-box postulated annihilation scenario to explain why in our crystal matter dominates has to be invoked.
(iii) In fact, this applies for all handedness questions of the standard model, for instance concisely summarized in the double simplex approach (Quigg, 2005), e.g. left handedness of W-Bosons. Again, in our domain this is how the crystal chose its symmetry cell. The other solution is equally possible, but applies to another crystal.

5. Physical implications and internal consistency tests for the theory

Importantly, for physics, generally a theory is only accessible or even testable if a mathematical framework is given (see next section for this). This can, in fact, hamper success and at least prevent credit for a theory, even if it is correct by normal reasoning. It is also a mistake to think that formula language captures all, every language is limited and ignorance of blank spots does not help to get a broader view of the world. On the other hand, of course our world can be much more complex then we imagine or can even understand, and in such cases, mathematics provides an independent consistency check. My claim is, however, that taking heuristics and hints from biology and solid-state physics of course can help to establish a far more reasonable and convincing cosmology and theory of the universe then currently available.

However, to raise interest and make such consistency checks possible, I explain here some implications and validation possibilities (Table 2).

5.1. Suitable string interaction potential replaces "Big Bang" and triggers crystal formation in quantum foam "ocean"

5.1. Postulate 1 (string interaction): Clear formulas are available, in particular from string theory. However, we have here a more general case: Usually the string theory wonders how our world is described. Which means that it postulates that we have 3 dimensions of space, one of time etc. and tries to fit this by a mathematical formalism.
Instead here is the task to devise a generalized string theory (really all possibilities of strings to become strings, branes, multidimensional etc.), create all sorts of fields (or not) and estimate whether they can interact or not.
Interestingly, for this general case there is a nice proof by Hurwitz, which considered all types of numbers. In particular, beyond real numbers there are only possible complex numbers and hypercomplex numbers can only be quaternions or octononions. There are no further solutions possible as proven by Hurwitz (**IIa**).
Interestingly, our observed world fits exactly an E8 symmetry.
One can interpret this as the most complex solution how generalized strings can interact, if they interact at all. The most complex solution (Oktonions) is necessary as we want to allow complex processes such as life and our own brain.

5.1.2 Postulate 1 quantification:

However, now comes the "real problem" (as anyway for the string theoreticians studying the E8 symmetry, one of five solutions all contained in the M-theory, but clearly due to its symmetry and relatedness to the E8 symmetry of elementary particles including super-symmetry the most popular one):

How do I now derive from the effect that generalized strings can only interact if yielding either R, C, quaternions or E8 symmetry any observables?

Well (see part 4) the speed of sound in our "world crystal" should be of course c, the velocity of light and derive quite naturally from the resulting crystal properties (the tighter packed, the higher the speed etc.).
Similarly, the amount of freezing implies how small h dash is: if it would be completely "real", completely frozen, then no quantum physics would be needed, but such an infinite tight crystal forming in the quantum foam surrounding is again not possible.

5.1.2.1. Magnetization and boundaries define E8 symmetry better:
For this, postulate 2 presents the "real beef" (see below).

5.1.2.2. Asthekar repulsive String potential defines String-interaction potential better:
Another possibility is the paper by Asthekar et al. (2006) describing how strings interact **(II*)** and even resist the big crunch **(IIa*)**. Thus, we can derive from this at least a couple of parameters describing their repulsiveness and counter-force, posing first limits on the parameters of the E8 theory.

5.1.2.3. Asthekar repulsive String potential defines the vacuum string soup better:
Note that postulate 1 demands that the Strings are eternal and ever there, this is derived by Asthekar by a completely different line of reasoning. This poses then some limits on the parameters and activities of the quantum soup.

So, more generally, many efforts want to derive from the E8 symmetry parameters so that they can explain why our observed world has exactly these parameter values. However, from my theory, we have in addition 3 quantification options

5.2. Weiss zone-like growth of the crystal replaces inflation and is self-limiting

Crystallization ensures that everywhere in the crystal are the same symmetries, so no inflation is necessary. The growth of the crystal happens by a magnetization-like process of loop quantums so that they now all interact. The growth is self-limiting by long range forces becoming stronger and limiting the growth.

Postulate 2 (Weiss zone growth) quantification:
5.2.1. Magnetization and crystal growth parameters:
Yes, for magnetization growth (formula **VII)** and for crystal growth **(iii)** nice formulas are available and we can mathematically describe well where the long-range interactions limit further growth promoted by the short-range interactions **(VIIa)** stemming from the phenomenon described in postulate 1.

5.2.2. **Magnetization and crystal growth parameters limit the parameter values for the E8 string theory**
However, importantly, these formulas compared *with the formalisms for the E8 string theory* should select from the many parameter values for the E8 symmetry only few that are compatible with the crystal growth parameters.

5.2.3. Concept of Time *within* the crystal: As the crystal condensates, all microstates "freeze-out" and become defined. They form the crystal layers, separated by one Planck´s quantum (denoted by h dash) from each other. However, the freezing is not perfect, *within* one h dash there is still liquidity, all states are possible, the quantum soup is still there (as it is outside the crystal for any amount, full liquidity).
The frozen-out microstates allow to distinguish between low entropy states and low entropy states and so you then get time *within* the crystal (**Figure 4**): Each world (layer of the crystal so to speak) is a succession of microstates from low entropy to high entropy, and as it is almost fully frozen out, there is a clear history and a clear future.
For envisioning the crystal better, you have to appreciate that each system state freezes out from high energy, low entropy down to low energy, high entropy (where there are very many microstate representations possible). Thus, you can imagine them as states piled upon each

other, there are many but clearly separated, distinguished high energy states ("start of time" within the crystal) and few, high entropy states with low energy and very many representations). This is an economic view at the full crystallized world, the succession of the system states next to each other, piled up according to entropy (or number of microstate representations). If the crystal crystallizes, then of course all these representations crystallize together. However, each specific "world trajectory" is one edge on the corners of the system representation. As the edges of the crystal freeze out, too, like everything did, provided the n-D strings interact at all, each trajectory is also clearly defined, and this is then one world line ("One fate" so to speak) of the whole microstate ensemble. This is then the "time within the crystal": Each different fate or world trajectory forms one "edge" of the crystal, each follows an own "arrow of time" and is one fate of the world (not changeable, frozen-out) and one series of events for the given number of quanta that interact and form the crystal. It is important to realize that we are very economic with this concept of "time within the crystal": It is completely sufficient that a given number of quanta crystallizes, then automatically the layers of the crystal form (different system states are now separated and not mutual overlapping like in the quantum soup) and as the corners, edges of the crystal also crystallize at the same time, the very high number of world trajectories solidify also, connecting the system states to each other following the arrow of time given by the natural entropy of the system states.

5.2.4. World trajectories allow individual "internal time" in the frozen-out state: There is only one world, one determined number of quanta (**Figure 3**). the quanta form usually together an unrestricted, coherent state of complete superposition of all possibilities, the perfect harmonic wave function of all states for the whole ensemble of quanta. However, if there is the nD-string interaction, then the ensemble undergoes solidification and becomes decoherent, "frozen-out". This alone is sufficient that at the same time a very high number of different "fates" and "world trajectories" solidify as the specific "time within the crystal" for each world. So: Really economic, one solidification event creates all the worlds and their fates for the fixed number of quanta. There is no mad multiverse with an unthinkable and almost unlimited number of worlds splitting in every quantum decision event. This is in my view clearly nonsense. Instead, there is one crystal, its crystal layers (system states) and its edges, each a different "internal time" and "world trajectory". The crystallization process is self-limiting according to the laws of magnetization and limited by long-range forces which can only form if the crystal crystallizes (like in normal crystal growth) according to formulas for crystallization **(I), (iI)** and growth **(III)**, but now modified for n-dimensional strings/quantum foam, in particular **(II**)** and **(IIa**)** (n-dimensional string interactions and repulsive forces).

5.3. Crystals may seed their next generation

This evolutionary argument is completely independent from 5.1. and 5.2., so an independent additional feature this theory suggests.

Postulate 3 (Evolution of the crystal):
As explained in part 4 there are good philosophical arguments that a universe that exists only a limited time (14 billion years) will also end after a certain time (**Figure 1**). Similarly, if you think that our universe is there only once and never again, principles such as the Kopernikan principle would argue against it: If there is an eternity, the probability, to be just in the unique event of a once for all and off again universe with finite existence is as close to zero as you want. However, again, I start from biology/ everyday physics and both proteins are created again and again, but also crystals can easily form **(II)** and grow **(III)**, they can decay, in

particular by dissolving in the solution again **(IIIa)** and they are (different place, different time) often formed and "happening" again. Thus, this is from biology anyway clear.
Here we have now a completely different concept of time: Time outside of the crystal. No matter if Newton´s notion of "absolute time" is accepted or more the Aristotelian time concept (time exists only if I can compare change to things happening), the time outside can be easily felt inside the crystal: according to my theory by tugging of the chaotic quantum soup from outside on the solidified crystal, the tugging dissolving the crystal. My conjecture, according to the "big rip scenarios" by dark energy is that this time amounts to 70 billion years of our local time within the crystal. As soon as this time limit is reached, the edges of the crystal dissolve, too (so the "different world trajectories", "fates").

Postulate 3 quantified:

5.3.1. Lee Smolin´s parameters from black-holes as baby universes: This has already been examined by Lee Smolin in his seminal 1997 book (and check his papers) but he had a different evolutionary process, the creation of a high number of black holes, as he conceived each of these as a seed for a new universe. I am happy to acknowledge him as the first thinking on such an evolutionary concept. However, at the very least you run into quantity problems with such a black hole evolutionary concept, as you then have smaller and smaller pieces of the original universe being blown up to a next-generation universe. Moreover, there were not many parameters (K meson decay was one) one could derive from his black-hole-universe seed model. It is also not clear (at least for me) whether just the quantity of black holes counts or more the size of the individual holes etc.

5.3.2. Own crystal parameters: If we believe postulate 3, then we need to compare the spontaneous rate of condensation nucleus formation (see postulate 1, some first assessments are given) with the enhanced rate of formation by the fact that we have already a crystal. Note that according to my theory, we have not the problem of shrinkage or smaller and smaller baby universes per generation, as in each new generation after generating the condensation nucleus there is a magnetization-like growth phase for the nucleus and the crystal growth for some time until long-range forces stop the growth (as in normal magnets or crystals). However, please remember: These are very abstract, high-dimensional crystals. The group symmetries and unit-cells represent the "laws of nature" for this universe and as a crystal has everywhere the same symmetry you have the same laws of nature without inflation, just by the normal crystal growth. Note also, that this "growth phase" applies only to exactly the same very early period which you used to call "inflation period". After this period of crystal growth has stopped, then by the laws of general relativity the normal expansion of the universe will start (as observed and validated by astronomical observations).

An important point is also the decay of a crystal: Usually the crystal either breaks (see below) or is dissolved again by the solution around **(IIIa)**. One could calculate the entropy force by the string soup "outside" around the crystal and how quickly it would dissolve the crystal **(IIIa*)**. These parameters should (my conjecture) be quite compatible with the blow-up by dark energy. Again: very difficult to calculate because the claim would be here that tugging and trying to pull apart the abstract crystal lattice by the string soup outside would roughly correspond to the calculated current increasing expansion rate by dark energy **(IIIb*)**.

5.3.2.1. **Crystals may break or crumble:** To treat this, we can write here all what is known from crystals regarding breakage and overall stability. We would focus particularly on breakage from the surface of the crystal **(vi)**, derive from normal crystals then parameters for the breakage of a crystal made of E8 symmetric strings and check how they break adapting

the string interaction potential **(vi*)**. These boundary conditions for the crystal have anyway to be closely evaluated, they modify the stability of the crystal which is strong "inside" the crystal. For an easy view on the "internal time within the crystal" I suggested to look at the edges of a normal crystal. But I thought there of edges as stable as the rest of the crystal, nicely solid. For the crystal breakage rate, we instead have to consider real rapture and break away events from normal crystals and then transfer it to the string interaction scenario.

5.3.2.2. Crystal breakage rates via black holes or at the crystal surface

Black hole formation may be another possibility to separate from our universe and become a condensation nucleus.

Note that our theory makes crystal-clear that a black hole is not really separated from our universe, it is still noticed by its gravity, particular in its vicinity.

Instead, if it is even more heavy (another postulate, would be No. 4**),** maybe there is a 2nd phase transition of the black hole, it is not only hidden from light, but the quantum theory becomes more dominant then GR (general relativity) and the condensation nucleus is breaking away (conjecture: may be only galaxy nuclei are massive enough for this. One could notice such a 2nd phase transition by a certain mass-defect of the breaking away part of the galactic nucleus (may be – and will it be only the "interior" part of it?) – very tough calculation to get here the parameters correct. Fascinating idea:

The 2nd state of a black hole where GR is overwhelmed by quantum effects and the hole leaves our universe **(VIIIa*)**. However, this may also be completely wrong, as we do not notice gigantic mass-defects in galactic nuclei. Hence, as an alternative there can either be only a very "smooth" solution permitted by the equations for breaking away via this black hole route from our universe or this suggested break-away route is simply not physically reachable in our universe (mathematics still has to proof which applies).

Interestingly, we can discuss also a second radius different from the event horizon or the Schwarzschild radius: The minimum radius of the black hole where quantum effects become so strong that they counter-balance the forces of gravity and actually prevent that a black hole becomes "point-like" (or becomes denser in this central region). The paper by Asthekar et al. (2006) gives there a first hint how one would calculate this, but probably nD-string corrections will be necessary **(VIIIa**)**.

Event horizon and GR are only there and valid, as long as the crystal is healthy and intact, thus just not for highest energies. At the rim of the black hole I have the event horizon. As long as the forces and energies are not too high (how high is still to be calculated), nothing else happens. But important is already the result above:

There are repulsive forces preventing a singularity (IIa*), it is clear, that the hole doesn't purr together on a point.

Strings are indestructible (in my theory as well as in Ashthekar's (2006) treatment, formula IIa*). More clear: they are the matrix of the crystal, respectively its loop quantums. Therefore, they can NEVER be destroyed by forces in the crystal and also outside, in the quantum soup, they are the components of the quantum soup. And exactly therefore NO information is lost. At most, the loop quantums (or strings, depending on the formalism used) lie very close to each other, that's all.

But it is conceivable at high enough energies that there is a second phase transition, at which the fabric of space and time is torn as the crystal itself no longer stays intact. Such a second phase transition is not meant as one of the well-known but somewhat obscure alternative solutions of GR space time found by Penrose and others, i.e. white holes and wormholes,

which may connect far distant areas, though infinitely thin and so on: These alternative solutions presuppose that GR stays valid, thus the crystal remains intact.
There are two places where the crystal and hence its fabric of space and time changes:

a) All edges of the crystal need a boundary treatment to understand the stability of their stable and smooth crystal surface **(vi)**. So that there is a steady transition to the chaos soup, one needs the appropriate formulas, which are again the * cosmology solutions to the normal phenomena, as it is in a normal crystal in the solution or salt grains in water. It is examined as a third postulate the possibility whether grains do not detach anyway from the crystal surface **(vi*)** to become germs for new generations of crystals and such a break-away of crystal crumbles can again be examined by using the normal every day crystal breakage formulas and transferring them to their cosmological counter-part **. Similarly, the entropic forces at the edge of the crystal want to dissolve it (IIIa*). This is reflected for us as "dark energy" and is treated above (IIIb***). For this speaks that the "dark energy" is so tremendously powerful in our universe, 75% of the energy. It is clear, it is the tugging of the soup, the ocean outside, what we see there, much bigger and more powerful than our small crystal universe.
b) However, in a sufficiently heavy black hole (e.g. M87*) this is conceivable, that then the crystal liquefies deep inside the event horizon or even condensation nuclei detach themselves even further inside and become nuclei of a new world. This would even take place "perturbation free" or little shaking ("smooth"), because within the event horizon. But one sees also the challenge: To punch out something within the crystal in such a way, also still gently, but cut-proof, I need clearly more force, than at the edge. And the hole that remains does not change the texture of the crystal beyond the event horizon at all, so it will not bend everything on the outside or be noticed from the outside.

5.3.2.3. Life and other self-organizing processes
This would be selected for, if life and other self-organizing processes enhance crystal formation (**Table 3**):

--5.3.2.3.1. intelligent life forms
Would be selected for, if they help the crystal to generate more crystals. For instance we observe that human beings can create artificial stars: yes, we apply hydrogen fusion and generate then hydrogen bombs (since 1953) or hydrogen fusion energy for peace (Stellarator in Greifswald; Costley, 2019; Kates-Harbeck et al., 2019; Surrey, 2019). We can imagine that there is may be a law of nature that intelligent life can use any natural process for each own purpose and use (we could call this “Jule Verne´s law”). This would then imply that at some point in future either we or intelligent life in general could create artificial galaxies (applying dark matter to create a new galaxy nucleus) and ultimately new crystals (understanding dark energy, quantum soup entropy and how nD-strings have to interact to form a new crystal nucleus).
Now the fascinating point is that the crystal I imagine here as the basis for our world is in fact also a real quantum computer (!). This means that an individual civilization may long go extinct before reaching the high level of impressive technology to generate the next universe (according to this theory this just requires to improve and engineer the condensation nucleus for the next crystal, no miracle needed). It may even be so that many worlds with their world trajectory never allow any civilization to reach this high level. Nevertheless, if only ONE civilization in the whole crystal reaches this level, this will allow the crystal to have offspring and multiply. Of course, this is wild biology applied to the world as a whole, but in evolutionary terms, this makes sense and can explain fine-tuning: why a crystal is favored and in fact selected for in which not only life is possible, but intelligent life: In biology, all is selected for which enhances the fitness to create offspring.

--5.3.2.3.2. Normal life could just indicate high power-self organizing processes (stable stars, stable galaxies, stable planets and orbits) and this selects for better organized and hence better reproducing crystals
--5.3.2.3.2. Stability of stars, planets other objects selects for a stable crystal: parameter estimates are possible, but challenging
--5.3.2.3.2. Galaxy formation: in particular the effect of dark matter, selects for an important and stable mixed unit cell for the crystal, making seeding by crystals better possible but also enhances the probability of galaxy formation.
--5.3.2.3.2. Galaxy supercluster formation: Non-perfect crystals (all real crystals are like that) allows early on that some parts of the universe become more massive and form nuclei of super-clusters of galaxies and ultimately, galaxies.

Again: At least for the non-alive processes one can try (of course a lot of work) from my theory to derive parameter estimates and check how far they agree with observation, but possible (Table 2).

5.4. Derivation of basic constants of nature in our domain from this theory

The crystallization theory allows to derive basic constants of nature for our domain from first principles (Table 2; in this direction, relations to "emergent gravity" approaches):

5.4.1 h dash, Planck´s quantum:
The amount of freezing out of the crystal determines, how "real" everything is and how much all what is wave-like, fuzzy, undefined, is banned from our macroscopic world. It is pretty small in our own world.
So, to derive this quantity, you need to start with the n-dimensional string interaction potential and then you check, how strong the crystal freezes out according to this interaction potential plus the Weiss zone growth plus the long-range interactions limiting the further growth of the crystal.
Hence this is a long calculation, but will help a lot to check internal consistency to find out whether you can come close to h dash

5.4.2. c, velocity of light:

As known from crystals, also for our abstract crystal, the sound velocity (maximum sound velocity) can be calculated. Nothing can travel faster in the crystal.
This is the "real" reason (according to my crystal theory) why nothing can travel faster then light. Moreover, the speed which then can be calculated should also be really close to observed speed of light.

5.4.3. vacuum energy

The vacuum energy is notoriously difficult to calculate and by a factor of 10^{120} too large by the popping up of much too many virtual particles.
The crystal theory gives again a clear reason: the popping up of the many virtual particles is the situation in the quantum soup. In our "real" world everything is in contrast crystallized and frozen out. So hence, solving the interaction potential plus the Weiss zone growth plus the long-range interactions limiting the further growth of the crystal should also give then a nice limit on the "vacuum energy", however, this time this denotes just the vacuum (matter and energy regions) *within* the crystal. And due to the combination of the three terms you

have there no large-scale popping up of virtual particles (decoherence, real world) and hence the vaccum energy gets as low as observed.

5.5. Support from Observation: large-scale matter distribution including super-clusters and dwarf galaxy arrangement

In general, the current picture of voids and filaments matches well to an ordered crystallization process while the amount of little aberrations from complete even distribution is really necessary though not convincing in the standard model. For real crystals it is instead well known that they have minor aberrations from perfect crystallization which later grow giving rise to large matter agglomerations with bigger and smaller superclusters but overall a nice texture of voids and filaments – a very big, but natural crystal-like structure, as expected and matching exactly what is observed.

Dwarf galaxies: Early problems were the high numbers of dwarf galaxies not compatible with textbook cosmology scenarios (Springel et al., 2005). After the disruptive forces of supernovae and other effects were accounted for. This point is now compatible with observations (e.g. Boylan-Kolchin, 2017; Kafle et al., 2014). In contrast, the particular arrangement of dwarf galaxies in a narrow plane and all circling counter-clockwise to the central big galaxy poses a problem, as this is well documented for three big galaxies and their dwarfs. However, such accurate arrangements are of course what is to be expected, if you think about an ordered crystallization process.

5.6. Discussion of the postulates

We clearly see that the three postulates of my theory are independent from each other: Each of them has good arguments from nature, in particular biology and physics, why it should be true.

(i) A condensation event (something seen **often** to happen) replaces Big Bang (something **never ever** seen by anybody in this universe).

(ii) This idea is independent from the magnetization-like growth of the crystal **after** the condensation event happened. Inflation “explains” by an extremely blown up quantum state (120 doublings of size, i.e. 10**36 blown up state, clearly wrong in my opinion) why there are everywhere the same “laws of nature” for our domain. Instead, magnetization-like processes of crystallization make sure that one unit cell and set of symmetries dominates the whole domain. Even better fitting observation, crystallization works never perfect and hence imperfections are ideal seeds for superclusters and later galactic nuclei.

(iii) Evolution and probably new generations of crystals explain why fine-tuning for self-organizing ordered processes happened in our universe.
This is plausible and evolution has been so often observed for life, for stars (e.g. look at the Hertz-Sprung Russel-diagram) and even galaxies.
In contrast, the standard cosmology has only to offer a unique freak accident to explain life-friendliness of our universe or just the notion that among a shockingly high number of observer-less and life-unfriendly universes, as everything goes and is possible, alas, there is one hapless strange universe which is our universe, that is giving birth to life.

Even if all my simple and first mathematical hints for this theory should not work out, I very much hope that a stronger physicist then me takes these three independent arguments as motivation to work out here the real solution and thinks beyond the well-known absurdities of textbook cosmology.

However, if we want to derive solid mathematical parameters we run into a similar challenge as the theoretical physicists working on the E8 string theory do:
We have very intricate calculations to do, and they are beyond most physicist capabilities.

But the big gain is: We are in a much better position than the string theoretician as I outlined a couple of concrete processes suggested from my theory which limit the parameter values for the E8 string theory and these parameters are quite independent from string theory itself and hence the promise is that then it is much easier to see, why our world has to come out as observed:

In fact, we could tackle the whole mathematics and the above treatment also using formalisms of quantum-spin loop theory. However, this treatment may be more difficult and the connections less obvious, though for instance **postulate 1** has support from results and work by Ashthekar et al., (2006) one of the leading loop-quantum-gravity (LQG) theoreticians.

The specific values are a result from selection processes among crystals (**postulate 3**) as can may be shown by direct calculations for the tasks sketched above but the required work is huge. Similarly, the explanation for dark energy is neat: crystals come and go and the tugging outside is seen inside like ever more rapid expansion by **dark energy**.

Even if we leave these considerations aside, **postulate 1** and **postulate 2** allow to reduce the freedom of possible E8 theories a lot. Note furthermore, that the two postulates are well compatible with observation, as we replace the inflaton at start by a generalized string interaction potential at start (postulate 1) and then the phase of rapid expansion by a process of magnetization and crystal growth (**postulate 2**).

After that, the universe expands completely like in the textbook (so after the first second), it follows only the laws of general relativity which drive the expansion.
Postulate 2 is far better compatible with observation then inflation as the start of the universe has no large multipole moments (BICEP/2 study and observations).
Postulate 1 (**string condensation nuclei** -- universes come and go, they are triggered by a condensation nucleus which forms only when conditions are suitable but eternal is the ocean, the boiling string soup vacuum where these crystals are only little islands) is a real explanation instead of a “big bang” from nothing. The quantum soup of “all possibilities at the same time” is in this sense pure creativity, and the crystallization to a “frozen-out” state the only possibility to become real and clear. My crystal has then crystal layers (each layer having then frozen out, clear world trajectories) with more similar world states in layers next to each other, layer separation is one uncertainty quantum, this is the remaining liquidity, uncertainty, “everything goes” left.

The "universe-crystal" has a symmetry group (like every mundane crystal needs to have). This has to be the E8 symmetry group, there cannot be a universe with e.g. an E9 symmetry or E111 etc. (this I can actually prove for the general case of octonions, which is the only break through the theory has, but this, put in physics language, would be a good start).

But this is a very abstract crystal, it corresponds
(i) to the observed E8 symmetry in particle physics, the famous SUSY -- and there I am betting on the E8 version:
https://en.wikipedia.org/wiki/Supersymmetry
as well as
(ii) the E8 flavor of String theory as a TOE for the whole universe, e.g.
https://aip.scitation.org/doi/10.1063/1.529784.
There is a scientific American article explaining this in simple words describing Cohl Furey as one of those young physicists following this trail
https://www.spektrum.de/magazin/oktonionen-koennten-geheimnisse-des-standardmodells-lueften/1626470
(I found and read here only the German link, nice story about her and the job-less bright young physicist, here is her home page https://www.furey.space)

This should be encouraging news for E8 symmetry researchers (e.g. Cohl Furey, see Wolchover, 2019) as I can explain WHY there should be an E8 symmetry in both cases as otherwise nothing stable can form from the quantum soup to yield a new universe. If generalized strings interact with each other, they can only do so with 1D, D2, 4D or E8 interaction fields (as mentioned, this is proven by the Hurwitz theorem and may be the mathematical reference given in (ii) thought regarding this mathematical aspect the same but impossible for me to say as too mathematical article for me).

Moreover, if you cannot derive any observables (Table 2) from this basic proof this would be a boring theory. Hence, as I am just starting towards the end of my sketch of the TOE, if you assume that really something like crystallization did happen for our universe to become real and defined, you can test each of the 4 postulates and then you should derive lots of restrictions which then constrict the theory.

If my guess is right, then you would then derive all the parameters necessary to derive "our" universe instead of just having an ocean of possible parameter values possible for the E8 symmetry.

However, this is a major undertaking only suggested to be done in my sketch.
So to make an impressive paper and grand unified theory and not just a stimulating hint out of this, one should develop the physical and mathematical leads further already sketched and check which parameter restrictions you get and how they can fit to actual observations.

On the other hand, the illuminating suggestions what is real and what is still undefined wave function in our universe (including its alternatives) as well as the general bridge of solid state physics to reconcile general relativity and quantum physics would be for sure exciting enough to write a more general and carefully formulated perspective if one feels capable enough to do this.

Similarly, the biological phenomena given are solidly investigated and the resulting cosmology formulas may be difficult to get, but each of these formulas (indicated by * as this is clearly challenging) can be derived independently looking at the biological or physics blueprint of the normal, well investigated phenomenon and its formula description.

Mathematical Tasks

This final section shows that there is a clear road here to a mathematical theory of the concept of our observed universe being one layer in a huge and abstract crystal with finite life time arising from crystallization nuclei in the otherwise chaotic and undefined quantum soup (**Figures 1-4** illustrate this basic idea). Part I of this section sketches the mathematical itinerary to go, Part II shows in more detail how then actual formulas are derived, tested and derived from each other and Part III sketches key formulas and mathematical challenges involved.

However, there are also formulas with an asterisk which are even more complex as they indicate to transfer the classical formula to a cosmological formulation, in general a formalism powerful enough for this, so either from string theory or from loop quantum gravity. This is then indicated by **(*)**. However, this just stresses how complex a detailed proper mathematical treatment of the theory developed here would in fact be.

Realistic formulas replacing short hand notation are examined here
(in this section **there are only the references and the formulas therein cited**)

We show → the critical mathematical challenges involved always in blue, recapitulating in black the stated mathematical itinerary above.

1. Typical protein folding formulas (I) to describe compact protein and rising entropy in the water around it are given by Dill (reviewed and applied in own work König and Dandekar, 1997).
→ The nice seminal work by Dr. Dill on entropy and protein folding (e.g. Ghosh and Dill (2009)) and his nice protein stability calculations shows how normal protein folding works.

2. Formulas to form a condensation nucleus in a crystal (II).
→ Condensation nuclei in a crystal (physics textbook formalisms, Meschede 2015; Kawasaki and Tanaka, 2010);

These have now to be compared to the N-Dimensional String Interaction potential which has, according to the Hurwitz Theorem (**IIa**), only the possibility if they interact, to interact as real numbers, complex numbers, quaternions or octonions
→ See the well-known Hurwitz Theorem from 1898 applied below to LQG (loop quantum gravity) as proof that interaction (or any mathematical operation) is only possible for real numbers, complex numbers, quaternions or octonions.

Quantum interaction in LQC (loop quantum cosmology) as much simpler to treat then string theory) is given according to the formulas by Asthekar et al. (2006) **(II*).**
→ Ashtekar et al. (2006) paper: The normal big bang scenario is extended by introducing a new Hamiltonian constraint operator (section II). Section III explains that the Wheeler-DeWhitt (WDW) theory still ignores the effects of quantum geometry. However, of major interest is here section IV where the loop quantum gravity treatment of the big bang is introduced. In particular quantum states which are semiclassical at "late times" are then numerically evolved backwards.
This then allows **estimates for the repulsive forces in LQC (IIa*) .**
→ Ashtekar et al. (2006) paper: The classical big bang is then replaced by a quantum bounce at an extreme matter density approaching Planck scale. In this deep Planck regime the quantum geometry is predicted to become strongly repulsive.

However, to find out how the quantum soup without any world, so the real quantum vacuum behaves, we have to modify both formulas to allow any number of dimensions **(II**)**
→ Ashtekar et al. (2006) paper pdf but allow any number of dimensions **(II**)**

and **(IIa**).**
→ Ashtekar et al. (2006) paper pdf but allow any number of dimensions **(IIa**).**
→ Potential corollary: maybe you can then show that for any octonions and unit cell resulting, the part representing gravity (U4 symmetry) has to be the weakest
(Wolchover, 2017; Crisford and Santos, 2017; many string theoreticians such as Cumrun Vafa discuss this topical idea, too)

3. Typical protein folding formulas to describe compact protein folding and rising entropy in the water around it are given by Ghosh and Dill (2009) **(I)** (reviewed and applied in own work König and Dandekar, 1997).
→ The nice seminal work by Ghosh and Dill (2009) on entropy and protein folding and Dill´s nice protein stability research (in fact Dill´s career was devoted to the topic) shows how normal protein folding works.

One can then for normal protein folding establish first the Schrödinger equation for a more folded protein chain (already difficult, but not impossible) and consider next the effects of entropy, in particular the disordered water shells which experience increased entropy as the protein folds, the main point why creation happens spontaneously inside the protein – and should also do so for our universe according to my theory, just by increasing the disorder "outside", in the quantum foam soup. Own work considered only a simple classical treatment of protein folding considering entropy and water shells (König and Dandekar, 1997). So already this first step is really a tough technical tour-de-force

However, one next has to carry these insights to a loop quantum cosmology (**LQC),** for instance according to Ashthekar et al. (2006), section IV.
Of particular interest is that in Ashthekar et al. (2006), section V then LQC wave functions are developed (formulas 5.12.a till 5.13b).
This would mean to transport the Schrödinger equation formalism of protein folding, considering also the entropy of the solvent, one step further, using the LQC wave function to establish the formula **(II*).** Below it becomes clear that for the "real quantum soup" probably even an nD-treatment is necessary, as without having our 4D world predefined, any interaction and dimension is possible and in addition actually there in the quantum foam as superposition state.
The standard efforts to calculate vacuum energy come up with an energy 10**20 too big to apply to our observed vacuum energy in our crystallized world (as there is an escalating number of virtual particles involved in the calculation).
The claim from my theory is that this high "boiling" estimate applies to the "real outside" undefined, fully coherent and super-positioned state of the quantum soup, the chaos our world derived from.
Moreover, even if establishing formula **(II*)** is really tough, the Hurwitz theorem guarantees that there are only four types of interactions possible and the most complex one are the octonions, allowing our reach world, the E8 symmetry.

Formulas to form a condensation nucleus in a crystal **(II).**
→ Condensation nuclei in a crystal (physics textbook formalisms, but there is also an interesting 1969 PNAS paper)

4. N-dimensional loop quantum interaction potential

These have now to be compared to the N-Dimensional loop quantum (or string) interaction potential which has, according to the Hurwitz Theorem (**IIa**), only the possibility if they interact, to interact as real numbers, complex numbers, quaternions or octonions
→ See the well-known Adolf Hurwitz Theorem from 1898 (Hurwitz, 1898 in reference list with detailed pointers to German and English versions) as proof that interaction (or any mathematical operation) is only possible for real numbers, complex numbers, quaternions or octonions.
Now, as the string treatment is challenging (at least for me) and only discussed here, there is an easy and elegant LQG (loop quantum gravity) treatment possible following definitions and formulas introduced by Rovelli (2004):

A background free (BGF, without time) spin-network is introduced (see Rovelli, 2004):
Dynamics (so things happening for a particle or a system of several particles in a space-time like our everyday world) are described in the spin network as follows (the amplitude, as shown by Feynman, encodes full quantum dynamics) and we write for the amplitude w (s) of spin network states (formula 1.12. in Rovelli, 2004):

$$W(x,t,x',t') = \langle x|e^{-\frac{i}{\hbar}H_0(t-t')}|x'\rangle = \langle x,t|x',t'\rangle.$$

In this notation, the particle is first observed at x´, t´ and then found at x, t.
The resulting space of events (x´,t´, x, t) is called G and includes (as long lists) all data-sets of the events.

For another variable different from the position, the Amplitude becomes

$$A = \langle \psi_{\text{out}}|e^{-\frac{i}{\hbar}H_0(t-t')}|\psi_{\text{in}}\rangle.$$

(1.13; Rovelli, 2004)

(requiring then the tensor product of the Hilbert space of initial states and (the dual of) the Hilbert space of the final state).

The physical transition amplitudes w (s,s´) are obtained by summing over spin foams bounded by the spin networks s and s´

$$W(s,s') \sim \sum_{\sigma \,:\, \partial\sigma = s \cup s'} \mu(\sigma) \prod_v A_v(\sigma).$$

(1.17; Rovelli, 2004)

--Now all this treatment of the spin network according to the LQG formulas above *does not* specify here a specific dimension (the G, the dataset could be collected and applied to study events in a space-time of any number of dimensions). However, to calculate amplitudes we have to sum up between states in the spin network to follow a succession of events.
The new concept introduced by me here in this paper is now to allow (x´, t´, x, t) over any number of dimensions and then we see immediately that the summation over amplitudes as given in 1.17 can only work if the mathematical operation of summation is possible despite the high or low number of dimensions chosen.
Strikingly, according to the Hurwitz theorem this is only possible for 1,2,4 or 8 dimensions.

Specifically, following Hurwitz (1898) we consider transformations A such that they fulfil the equation

$$AA' = (x_1^2 + x_2^2 + \cdots + x_n^2)$$

(formula (4) of Hurwitz, 1898)

This implies that we have to satisfy the equation 9 of Hurwitz

$$B_i^2 = -1, \qquad B_i B_k = -B_k B_i, \qquad B_i' = -B_i. \qquad (i \gtrless k)$$

which, as Hurwitz shows, is only possible, apart from real numbers (so dimension 1) for dimensions 2, 4 or 8 (for other values you get undefined division by zero etc.).

So, in summary, the LQG formalism allows any dimension in its formulation, such as for the interaction potential, the datasets of events and the amplitude for other properties then the position. Knowing this and then applying the Hurwitz theorem to it shows then that any summations or any more general mathematical operations are only possible for dimensions 1,2, 4 and 8. Hence LQG or any type of many-dimensional string interactions or many-dimensional spin networks are only possible for 1,2,4 and 8 dimensions or symmetries. The last one corresponds to the richest case and is our observed E8 symmetry of our domain.

Similarly, and as the next step, the Interaction of the basic building blocks and strings is given according to the formulas by Asthekar et al. (2006; which is hence a LQC treatment): **(II*).**
→ Ashtekar et al. (2006) paper: The normal big bang scenario is extended by introducing a new Hamiltonian constraint operator (section II). Section III explains that the Wheeler-DeWhitt (WDW) theory still ignores the effects of quantum geometry. However, of major interest is here section IV where the loop quantum gravity treatment of the big bang is introduced (loop quantum cosmology, **LQC**). In particular quantum states which are semiclassical at "late times" are then numerically evolved backwards.
This then allows estimates for the repulsive forces **(IIa*) .**
→ Ashtekar et al. (2006) paper: The classical big bang is then replaced by a quantum bounce at an extreme matter density approaching Planck scale. In this deep Planck regime the quantum geometry is predicted to become strongly repulsive.
→ *As can be seen by the formulas 5.12.a till 5.13b by Ashtekar et al. (2006), these are typical wave functions derived for the **LQC**, so resolving numerical issues after evaluation of the Eigenfunction (Section V, subsection A) and the evolution estimate (B). This then allows numerical simulations and plots such as Fig. 6 in Ashtekar et al. (2006).*

However, to find out how the quantum soup behaves without any world, so the real quantum vacuum behaves, we have to modify formulas to allow any number of dimensions **(II**)**.
→ *This implies to transform the quantum wave functions and formula 5.12a till 5.13b but now becoming open for any number of dimensions. The big bounce should still hold, described by* **(II**)** ***as already seen by Ashtekar (2006) for LQG and also shown in this paper:*

Hence **(II*)** denotes the formulas by Asthekar et al. (2006) describing how strings interact **(II*)** and then the next point in the paper shows how this may even resist the big crunch **(IIa*).** Specifically, only in section IV of this paper (Asthekar et al., 2006) the authors return to LQC (Loop quantum cosmology) and construct the physical sector of the theory. The LQG (Loop quantum gravity) Hamiltonian constraint is given by eq. (2.34)

$$\partial_\phi^2 \Psi(v,\phi) = [B(v)]^{-1}(C^+(v)\Psi(v+4,\phi) + C^o(v)\Psi(v,\phi) + C^-(v)\Psi(v-4,\phi)) =: -\Theta\Psi(v,\phi), \quad (4.1)$$

This is just a first glimpse how then **(II*)** would have to be formulated using LQG. However, this formalism has then to be transported to an interaction field more general then our world with any number of dimensions.
and only section V shows then how quantum states which are semiclassical at late times are then numerically evolved backwards, starting from eigenfunctions (and using these in simulations on a lattice):

$$e_\omega(v) \overset{v\gg 1}{\to} A\underline{e}_{|k|}(v) + B\underline{e}_{-|k|}(v), \qquad e_\omega(v) \overset{v\ll -1}{\to} C\underline{e}_{|k|}(v) + D\underline{e}_{-|k|}(v). \quad (5.2)$$

The classical big bang is then replaced by a quantum bounce when the matter is extremely compressed to acquire a Planck scale density. This is then just a faint hint of how **(IIa*)** should look like in my new theory.

5. Long range interactions limiting growth of the cosmological crystal

An inherent challenge is to implement the build-up of the long-range interactions correctly, the classical treatment focusses on the energies. In the original Weiss theory the mean field H_e is proportional to the bulk magnetization **M**, where alpha is the mean field constant.

$$H_e = \alpha M$$

Then next, the size of the domain and the contributions of the different internal energy terms is described by the Landau-Lifshitz energy equation

$$E = E_{ex} + E_D + E_\lambda + E_k + E_H$$

The total energy is composed of E_{ex} (exchange energy; critical for the overall size, lowest when dipoles all pointed in the same direction. Additional exchange energy is proportional to the total area of the domain walls), E_D is magneto-static energy (self-energy, due to interaction of the field created by the magnetization in one part on other parts and reduced by minimizing overall energy, incorporating again large-range forces effects), E_λ is magneto-elastic anisotropy energy, E_k is magneto-crystalline anisotropy energy and E_H is Zeeman energy. Hence, detailed consideration of these energy terms allows to calculate the self-limiting growth of the Weiss domain by considering long-range vershs short-range forces.

b) However, taken to cosmology, there are challenging n-dimensional string interactions and repulsive forces to calculate **(II**)** and **(IIa**)**, a bit easier transport the classical formulas to a first condensation nucleus forms (**VII*)** and limitation by long range interactions **(Viia*)**. Moreover, a good hint is then to apply again LQG, as then the energy considerations are again far easier transported to interactions of any number of dimensions.

Note that we show here only a very general solution for the interaction field between loop quantums (or strings) and how they can form a crystal, where there is also again a size limit after crystallization. The mathematical formalism derived here allow many different parameters to fulfil it. According to postulate 3 we need this open-ness so that evolution over several generation can operate on the parameters to select optimal crystals with best reproduction rate, stability and resulting overall fitness. The result is fine-tuning: The optimized crystals are particularly favorable to life.

Note also, that the basic unit cell of the crystal with its free parameters represents then one form of encoding the properties ("laws of nature") of the crystal. However, also surfaces of the crystal ("membranes") can influence the next generation of the crystal ("break away seeds"). This has the advantage that more detailed and specific information (and hence adaptation) can be transferred including a specific arrangement of world-lines reoccurring in the next generation of the crystal. Interestingly, this includes then also world-lines imprinting the success or failure of complex processes such as life and evolution or even an intelligent civilization in the next generation of the crystal. Phrased like this, this may sound quite esoteric, but it is just resulting from the surface properties of the crystal according to this theory, imprinting on the surface of the next generation of crystals (different possibilities exist for this process of imprinting; normal crystals and the triggering of crystallization by condensation nuclei allow this to investigate including rain and rain cloud formation).

6. Next, we need **formulas for growth of such crystals (iii)** and their **dissolution (IIIa)**
→ Condensation nuclei in a crystal (textbook formalisms; Kawasaki and Tanaka, 2010) but this is now taken from the normal physics to cosmology using a string theory or loop quantum formalism **(IIIa*)**. We consider here a rather abstract "crystal", representing our whole observable universe and beyond, so the whole domain we live in. The symmetry planes in the unit cell of this abstract crystal represent all our conservation laws. Again, we think that such a basic, symmetric formation of a crystal achieves to have the same laws of nature everywhere instead assuming a crazy, never observed inflation process in the early universe.
→ Condensation nuclei in a crystal but now taken from the normal physics to cosmology using a string theory or loop quantum formalism **(IIIa*)**.

The big advantage after doing this is that **the observable ("crystal decay")** should correspond to our dark energy "force" and should have increased the last 7 billion years **(IIIb*)**.
→ Condensation nuclei in a crystal (physics textbook formalisms) but now taken from the normal physics to cosmology using a string theory or loop quantum formalism **(IIIa*)** and then looking at crystal decay **(IIIb*)**.

7. Formulas for unit cell properties in a crystal (iv). According to our considerations above, this should come out comparatively easy, analyzing the symmetry properties of the resulting mathematical formulas as they should describe the formation of the abstract crystal we live in correctly. Hence, look at **(IIIa*)** and **(IIIb*)** and derive symmetry properties to yield the unit cell of the crystal **(iv).**

8. Formulas on unevenness in the crystal (displacements) (v) and now transform this to our string-theory or quantum-loop-gravity-like description of our universe as a crystal **(v*)**.
→ Challenge, you need **(iv)** (or in reality **(iv*)** cosmological formulation) and derive unevenness in the crystal (displacements) **(v).**

b) But as a classical short-cut you first simply start with normal crystal **(iv)**, look for displacements and see how these create tension modules in a normal crystal **(v)** and how this displacement translates into a gravity potential of a galactic supercluster, cluster or galaxy nucleus **(v*)**.
c) Moreover, you could of course try to see how these considerations **(v*)** would predict the cosmic background radiation and how turbulent it would be etc. and hopefully that fits well to observation.

9. Formulas for normal crystal breakage rate (vi), however, the cosmological formula **(vi*)** becomes then already rather challenging as it has to consider **(II**)** and **(IIa**)** (n-dimensional string interactions and repulsive forces).
→ again, this will be just tough mathematics, first of all string theory or quantum spin-loop formalism for the cosmological crystal breakage rate **(vi*)**.
b) However, the n-dimensional generalization is really a BIG challenge **(II**)** and **(IIa**)** (n-dimensional string interactions and repulsive forces).

Formulas for growth of a magnetic zone (**VII)** and for crystal growth **(iii)** but now considering limit of crystal growth over certain sizes by long-range interactions **(VIIa)**. However, this is now taken to cosmology, which means that you start again with the n-dimensional string interactions and repulsive forces **(II**)** and **(IIa**)**, derive from this the magnetization-like growth of the crystal as soon as the first condensation nucleus did form (**VII*)** and its limitation by long range interactions **(Viia*)**.
→ classical formulas for growth of a magnetic zone (**VII)** and for crystal growth **(iii)** but now considering limit of crystal growth over certain sizes by long-range interactions **(VIIa)**.

Moreover, a good hint is then to apply again LQG, as then the energy considerations are again far easier transported to interactions of any number of dimensions.

11. Formulas for a black hole (VIII) (rather well known), but now, according to my theory, there may be is a **2nd phase transition within the black hole**, it is not only hidden from light, but the quantum theory becomes more dominant then GRT (general relativity theory) and the condensation nucleus is breaking away from our universe, no longer gravity reaches out from it to our universe **(VIII*).** Probably, this should be a smooth, non-disturbing separation, e.g. for supermassive holes like the M87 galaxy, there should be (almost) ***no*** mass-defect visible from the amount of matter that separated from our universe **(VIIIa*)** as we have no evidence for such a defect looking at supermassive galactic holes (radiation clearly comes from the gas falling into it, but no large gravitational waves emanating after the hole is formed).
→ classical black hole formation formalism **(VIII),** there should be a 2nd phase transition of the black hole **(VIII*)**. To construct this smooth, the guiding picture is a droplet that separates from a liquid. Key is that the mother liquid simply keeps the steep curvature of the black hole and so the droplet forms beyond the singularity and can hence separate without creating outside turbulences. Only way to mathematically check for this possibility: Do the formulas **(VIII*)** indicate this possibility of smooth separation of new droplets/condensation nuclei from the crystal? Or is this point never reachable, are only flanking sides of the crystal (like in real crystals) able to crumble and break away? Similarly, the "quantum radius" of a black whole including nD string theory corrections and would give a radius smaller then Schwarzschild, but substantially larger than a point **(VIII**)**.

12. Calculation of observables (Table 2):

a) to look at the unevenness, natural displacements of the crystal **(V*)** and calculate the resulting structure of voids and filaments **(Va*)**. This should come easier and more natural then looking for tiny, tiny unevenness of quantum fluctuations after the postulated inflation period (which in my theory of course never happened). Similarly, one should check for the amount of dwarf galaxies **(Vb*)** and their orientation (in particular if perpendicular by crystal orientation reasons to the central normal galaxy).
b) Calculate velocity of light from speed of sound in the crystal: After its formation **(II**)** and **(IIa**)** and structure modification after sufficient growth you have a compact crystal **(VIIa*)** and if the compactness was calculated correctly, your derive the speed of sound in this crystal **(VIIb*)** correctly to be exactly c.
c) Calculate h (acting quantum) or h dash from the amount of freezing out of the crystal ("how real it is" and how much wave-likeness remains at really small dimensions), so the same mathematical lead **(VIIa*)** as to derive c **(VIIb*)** but now calculate how "solid"/frozen out the crystal is (normal formula would be **IX**), but the cosmological modification **(IX*)** should look very similar to a modification of **(VIIa*)** into **(VIIb*).**

→ All these are non-classical cosmological formulas, really challenging, not easy to model and only if you have them you can test and compare the predicted crystal displacements **(V*)** with observations such as voids and filaments **(Va*)** and the amount of dwarf galaxies **(Vb*)**. In particular, galaxy formation, and even more so galaxy cluster and super-cluster formation happened fast according to older and even more so recent observations (see e.g. Long et al., 2020) and clearly too fast if they would have started from an inflation scenario (which would even out everything) whereas crystal displacements would act as natural ingredients for such rapid galaxy formation from the start of crystal formation – and are very plausible, every natural crystal is NOT perfect but has a number of such displacements as soon as it forms. Note that these displacements would influence the matter distribution (as observed, much earlier galaxy formation) but not the unit cell (the basic symmetries governing the crystal and getting rid of an inflation scenario to explain why everywhere there are the same basic symmetries).
The crystal paradigm allows also to calculate and derive from the crystal properties the velocity of light: starting from equations **(II**)** , **(IIa**), (VIIa*)** from the speed of sound in the crystal **(VIIb*)** as well as calculate h (acting quantum) from the amount of freezing out of the crystal ("how real it is") and how much "liquidity", i.e. wave-likeness remains at really small dimensions.

13. Validation considerations from quantum computing

Quantum computing is a hot topic (Pan, 2021) and detailed literature is there to calculate and estimate their computing power, allowing also clear results regarding the quantum computation process including the power of decoherence and stability of qubits in the coherent (complete superposition state).

These formalisms allow to probe our theory by concrete data from this field.

To compare these results to our theoretical results, we know that from our perspective the quantum computing happens in a real, condensed world, so the bound state ("crystallization event") ensures that we get the decoherence terms right. Which, according to the quantum computing physicist, is astonishingly high, happens very easy, indicating that the bound state according to our theory is very tight. Nicely enough, we can now quantify both perspectives and compare the result to fix parameters in our theory and find experimental observations and support for it.

For example, the commentary by Pan (2021) reviews how the problem of the notoriously noisy quantum computers is now better tackled: The noise caused by decoherence in qubits limits the number of entanglements or coherent qubits and thus the computing capacity
This is the estimate of noise according to conventional calculations, Yiqing Zhou and colleagues propose to use matrix product states (MPSs) tensor networks, to mimic 'noisy' quantum computers and decoherence in qubits (Zhou et al., 2020).
This compressed wavefunction from MPSs represents then the in fact still low to medium entanglement levels with an error rate per two-qubit gates. This approximation simulates well experimental quantum processors of one-dimensional and two-dimensional random quantum circuits and their fidelity.
For comparison, the cosmological calculation according to my theory looks like the following:
You start with the interaction potentials **(I*, II*, III*…)** according to their LQG formulation. These should give again the correct noise estimates for quantum computing inside the crystal. In contrast, the much higher noise level in the quantum foam, the soup outside is the free, unbound and full wave function in full coherence. Now the close comparison of our cosmological calculations (at present mainly on sketches of the mathematics required) with the free wave function outside gives a first estimate of the noise expected in quantum computers: In my view the superposition and coherence of quantum computation is only possible in our world as we are not completely frozen out, our crystal and its solid-state physics permit remaining liquidity and superposition. Now the free parameters of our cosmological calculations can be reduced by comparing the above classical calculations (Pan et al., 2021; Zhou et al., 2020) as well as with direct experimental measurements in such circuits including for instance topo-electrical circuits and corner modes (Imhof et al., 2018). To cite the authors of the last paper "*Our work therefore establishes an instance where topoelectrical circuitry is employed to bridge the gap between quantum theoretical modelling and the experimental realization of topological band structures."* We would follow this reasoning and think such experiments could also help to validate and step by step parametrize our currently still quite free and unparametrized LQG and QLC calculations.

14. Discussion of the mathematical aspects

This theory is replacing the singularity and Big Bang by a condensation event and inflation by subsequent magnetization-like growth of the crystal. Removing a singularity by a more mundane condensation event in the hot vacuum is more realistic and also not as ambitious as the Big Bang concept is: we do not describe how existence of the world starts from nothing or from eternal inflation (something even more strange then a singularity at start) but rather how our world may have started from a chaotic soup by a condensation event and subsequent crystal growth.
This growth phase has also not to happen superfast as does inflation, any typical time-scale for crystallization or magnetization processes is fine. As explained above, the framework in which the magnetization happens is a quantum spin network that is background free and described according to LQG. Only once the growth process is over and the crystal well established, we have our world formed and only then general relativity (GR) holds and space and time exist (no longer background free). However, as soon as GR holds in the well-formed crystal, there has to be expansion, according to an Einstein universe and avoiding a cosmological constant.

Note that after this, normal textbook cosmology takes over: A very hot early universe with an energy level and density just above grand unification of all four forces. Hence, all later events agree also with current wisdom and observation, while the "early" events of big bang and inflation are replaced by more reasonable processes. The failure to detect inflation

disturbances or strong multipole moments in cosmic background radiation supports in general all inflation-less scenarios.

Creation of the world from something, in this case the boiling vacuum, is intellectual far more attractive than a singularity created from nothing. Moreover, the theory has an even more convincing perspective: condensation of qubits. To do so, they first have to interact and next the result of the interaction is decoherence, a clear separation of the coherent, ambiguous qubit states to defined states, so a "real", defined world. This is always how things get real in quantum physics, in particular any result of a quantum computer means starting from the superposition "all states" to the clear, decoherent state of the output, the result. If you really think about it: this is the only way how our universe could have started and become real.

Besides the more concrete mathematical considerations above, this paper provides mainly useful heuristics to find the next unified theory and cosmology of the universe. It is far from any closed or fully mathematical description of it. It should also be noted that there are of course a stream of later and even more complex papers and mathematical treatments of LQC, but the reason to pick Ashtekar *et al.* (2006) was more that this is an easy to understand first start how a LQC treatment would look like for my theory.
We give here, due to own technical limitations, no mathematical treatment according to string theory, as this is again far outside our mathematical capabilities. However, the important point is that this more demanding mathematical treatment would allow to check all the results of the LQC treatment as it still describes the same remarkable fine-tuned universe we live-in.

In very general terms, the perfect wave function of really "all" possibilities exists only in the quantum soup "outside" of our domain or our universe. This is then broken by the crystallization event that did form our universe. All is now no longer perfect and coherent, but real and decoherent. Different solidified world lines are separated by h dash, Planck´s quantum. Hence, our "real" universe, in its decoherent state is digitalized, there is no longer a perfect continuum, only the limited number of states of the quanta which interacted and formed our universe are accessible. The wave function is hence also no longer perfect, but came to a bound state, nicely separating different world trajectories and events.

Moreover, the total size and stability of the crystal allows to define the *a priori* probability to exist in a certain crystal state or type of "universe", i.e. domain forming as crystal from the primordial chaotic quantum soup: the more stable, more replicative ones have a bigger slice (simply more quanta in their formation, in the bound state which solidifies, becomes real and is no longer coherent), so hence in a replicative big crystal universe, you have the higher probability to reside in as an observer, the interaction potential allows next even an estimate about the fraction of crystals compared to the number of quanta in the soup, all is possible to calculate accurately (but tough). However, looking at real crystal formation in our mundane everyday world, our default assumption is that the soup is much larger, but the crystals are also there (small part of the total space, but clearly there).

Finally, remember that we started from biology and biological selection: It is our major claim that selection processes and a type of evolution will in the long run explain the fine-tuning problem (there are of course more evolutionary cosmologies). Specifically, our scenario of world creation replaces a big bang by a condensation nucleus and inflation by magnetization-like growth. Creation of a remarkable ordered domain we live-in is explained by entropy considerations from protein folding:

All this makes inherent so much more sense and is natural and nature-like and agrees with observation of natural phenomena including proteins, evolution and crystals as well as our not

so disturbed early universe, suggesting much more smooth and natural processes for our early cosmology then a "big bang" and "inflation". Apart from this, this is an attempt explaining why reality and decoherence apply all over our domain and why the vacuum energy is so much higher calculated by standard physics: this applies to the quantum soup outside our domain, not to the bound solid state within the crystal where strings interact.

15. What do we get from the AdS/CFT correspondence regarding my new qubit decoherence theory?

Well, first of all the typical application to solid state physics is as follows, according to Sachdev and Müller (2008) *"many condensed matter experiments explore the finite temperature dynamics of systems near quantum critical points. Often, there are no well-defined quasiparticle excitations, and so quantum kinetic equations do not describe the transport properties completely. The theory shows that the transport co-efficients are not proportional to a mean free scattering time (as is the case in the Boltzmann theory of quasiparticles), but are completely determined by the absolute temperature and by equilibrium thermodynamic observables. Recently, explicit solutions of this quantum critical dynamics have become possible via the AdS/CFT duality discovered in string theory. This shows that the quantum critical theory provides a holographic description of the quantum theory of black holes in a negatively curved anti-de Sitter space, and relates its transport co-efficients to properties of the Hawking radiation from the black hole. …Insights from this connection have led to new results for experimental systems: (i) the vicinity of the superfluid-insulator transition in the presence of an applied magnetic field, and its possible application to measurements of the Nernst effect in the cuprates, (ii) the magnetohydrodynamics of the plasma of Dirac electrons in graphene and the prediction of a hydrodynamic cyclotron resonance."* In other words, this is an important technical short-cut which really can improve normal condensed matter calculations.

(i) Of course, at least the experts did know previously (Hartnoll et al., 2018) that the duality holds. However, we now give a clear explanation WHY: because our whole domain is a solid state of otherwise highly liquid qubits.

(ii) My theory now turns this argument around, our whole universe is only possible and real, as it became decoherent qubits, and hence a solid state of defined bits. In this view, the technical trick which works on the small scale and everyday application for solid state physics, should also work on large scale, also for the universe as a whole, this duality is real.

(iii) Hence, normal physics calculations such as (Sachdev and Müller, 2008) *superfluid-insulator transition in the presence of an applied magnetic field, and the magnetohydrodynamics of the plasma of Dirac electrons* can be transferred to cosmological considerations, in particular surface effects on the crystal and its boundary conditions, or the growth (magnetization) of it in its early growth phase. For this, it is important to transform the formulas of the review back to cosmology and the problems treated in II* (magnetization / rapid growth of early universe) and VI* (crystal breakage rate and other boundary conditions), for instance holographic spectral functions and infalling boundary conditions at the horizon / boundary of the crystal, Hartnoll et al., 2018).

(iv) Here the detailed mathematics is missing currently, too demanding for me, but for strong string theorists this should be attractive, as we then can apply the AdS/CFT duality to advance new aspects of cosmology using string theory.

16. Attractive new routes to solutions of long-standing problems

Our crystal theory is also very attractive to tackle the long-standing challenge of quantum infinities (for a review on alternative treatments see Jackiw, 1999; several more solution suggestions have appeared since):
We suggest that the build-up of infinities results from using the "wild quantum soup" creating infinities and iterative clouds of virtual particles creating other virtual particles including very high vacuum energies. The correct much lower (10**20 times lower) energy you obtain considering the bound state by the interacting loop quantums inside the crystal (formulas I* etc.).

The formulas of our theory are given currently in an underdetermined fashion. In particular, to fit the Hurwitz theorem any of the 1,2,4,8D solutions possible will fit it. No clear parameter choice. To nail this down, a number of parameter considerations are given, in particular close comparison with the more mundane real world phenomena crystallization and breakage, magnetization but also solid state physics in general and quantum computing. Similarly, our treatment relied heavily on LQG and LQC but this is no prejudice against the more fundamental string theory, only its mathematical treatment is even more challenging and not attempted here.

We replace here inflation by crystal symmetries to guarantee the same laws of nature in every place of our observation horizon or our domain we live in. This is definitely a viable alternative and, in difference to a number of other symmetry-relying theories (for instance all those GUT, grand unified theories relying on symmetry breaking to explain how at lower temperatures all four basic forces arise) we have a clear explanation WHY the symmetries hold: Due to the creation of our world by a crystallization-like process.

From a molecular biology point of view the phenotype is given and directed by the genotype. In this theory these are the basic crystal symmetries providing the laws of nature and hence the genotype which sets the stage on which all physics phenomena happen (from elementary particle trajectories to stellar orbits). However, please bear in mind that there is also genotype information present, in particular structural imprinting at the boundary of the crystal which can also influence the form and information stored at breaking away condensation nuclei for new generations of crystals. Hence, the information storage for evolutionary scenarios from our theory has two types of genetic or information encoding which can be passed on to future generations.

Main leads from this effort

This paper is typical for bioinformatics: We do not deliver accurate calculations but rather rapid predictions and hints. These should then be applied in the next step to find an accurate solution. All of the following hints fit well together, but are independent from each other. So if one suggestion proofs to be wrong in the end, you can follow the other hint.

(i) In particular, a hint for cosmology is that replacing the Big Bang singularity by a condensation event of interacting nD strings solves a number of philosophical problems, in particular there is no "creation from nothing" but rather we suggest a transition from an uncontrolled, chaotic soup ("before") to a clearly interacting "real world". Ib) Furthermore, as evidenced by phenomena such as magnetization and crystal growth there is also no unlimited growth but only until long-range interactions which are now possible inside the crystal do limit growth. Ic) The unit cell of the crystal is repeated naturally in crystals and stretches over

the whole crystal. This effect makes sure you have the same laws of nature and basic symmetries over our domain. Id) This phase of rapid and then suddenly stopped growth happens with few perturbations in normal crystal growth, is better compatible with the perturbation poor early cosmos according to observations and replaces very well the crazy and never in nature observed inflation scenario. Ie) Tiny mis-arrangements in crystals are natural and no magic and these present then the nuclei of superclusters and galaxies, much more realistic then explaining how this could happen in inflation. If) Crystallization arrangement can also nicely explain the arrangement of dark (halo regions) and normal matter (galaxy nuclei) so convenient for galaxy formation)

(ii) Crystals come and go, depending on how the properties and concentrations in the solution are and are never eternal. As our universe has a limited past, we suggest the same for its future. Like a crystal dissolves, there will come a big rip, triggered by dark energy which we, by looking at normal phenomena such as protein folding we identify as entropic forces from the solution trying to dissolve the crystal, our domain. IIb) Besides explaining dark energy and its growth this allows for an evolutionary cosmology scenario: If the crystal exists only finite time and there are a lot of crystals with slightly different properties possible, then over time those which provide the highest number of seeds will be the biggest population. This can explain fine-tuning: Exactly those conditions have been selected giving maximum offspring. IIc) In particular, this can explain that self-organizing processes inside the crystal are favored, allowing besides life also more easy generation of offspring. IId) One can even suggest that intelligent life is only favored as it also can help in creation of more offspring, after mastering star creation (hydrogen fusion), we master dark energy (galaxy creation) and then dark energy and string interaction (new crystal seed generation). IIe) It is sufficient if this happens in one world and one civilization of the crystal. IIf) The crystal is in that sense a perfect quantum computer (only limited by the total amount of quanta contained) calculating all possibilities for existence including also all quantum states for intelligent life and all the computers they ever can build.

(iii) Independent of cosmology, our theory is that crystallization explains also decoherence: The fact, that in our macroscopic everyday world we only see one reality. This contrasts strongly with the quantum world where you have coherence, a superposition of all quantum states. We suggest that a “real world” (so our everyday macroscopic world) happens only inside a crystal. “Outside” of our domain and our observable universe there is the quantum soup of boiling quantum foam and superposition of all possibilities. IIIb) We hence think that the calculation of the vacuum energy in quantum physics is not wrong, but rather applies to the quantum foam outside of our world whereas in the solid “bound” state of our crystallized world the vacuum no long boils but is cooled down by the crystallization and hence is 10^{20} smaller, exactly as observed in our everyday world. IIIc) As we live in a “solid” state, within a crystal, the different quanta which build our world have all their different states nicely separated. So this theory postulates there are only n quanta and m states available for them. This corresponds to n**m nicely frozen out world states made of n quanta with m states, but not more. In the solid state we live in, there is decoherence, the states are nicely separated. Outside the solid state, this corresponds, however and very economical, just to n qubits having all their states at the same time superposed. IIId) According to the arrow of entropy each edge of the crystal forms one fate, one clear development of a world, while the layers of the crystal are different system states (see Figure 4). Thus an internal time forms and a clear future inside the crystal. IIIe) Planck´s quantum and the uncertainty relation indicate the remaining liquidity of the crystal: each layer is separate by one h from the next and within h still all superpositions and possibilities are allowed. IIIf) the crystal is also a perfect parallel computer allowing all possibilities to follow their fate. Interestingly this is not an absurd large

Everett world of forever split decisions with ever new world creation but rather it is just the solid state version (each state realized, cool, concrete, decoherent) of the normally unbound liquid quantum foam formed of n quanta having m states. More is not necessary, in particular no higher amount of quantum states or many worlds. The Everett-type of multiverse is simply wrong in this opinion. Our world is one crystal with many layers and those are the different system states, while the different trajectories and world lines (individual fates of a whole world or a specific object) are just the connecting edges between system states, having a clear future, following the arrow of entropy. Only one crystal in the end, not more, made of n qubits frozen out in almost completely solid state and separated worlds and world-lines (internal successions of events, "time").
Defined states or, more philosophically phrased, "reality" is created by decoherence. As soon as the states are defined, you can also distinguish them (not meaningful instead in the quantum soup "outside" of the crystal): This creates also time (the "internal time" inside the crystal) and arrow of entropy (Figure 4).
Space is also not real in the quantum soup as any distance may be travelled within any time and two points are never really out of reach. Inside the crystal space becomes real as there is a maximum speed in any crystal, also the everyday salt crystal, its speed of sound. In our domain this is the speed of light, nothing can travel faster.
Moreover, the crystal paradigm restores harmony in the universe: you have the ocean of quantum chaos and in it, from time to time, crystals come and go, one generation of crystals laying the seeds for the next generation. This explains why every "local" world can start with high energy (powered from the condensation event), how it is dissolved again (entropic forces ultimately tear apart the crystal in about 70 Gyrs). So the conundrum how we do not stop just forever in an equilibrated state of comparatively low energy or expand forever is solved (if you believe this theory) and, at least philosophically speaking, harmony is restored: there is always an eternal cycle of come and go. In addition, by favoring the most efficient seeds for the offspring we explain why self-organization is favored including life-friendly processes within our world, our crystal – the central enigma of our own life that the textbook cosmology cannot explain and cannot even consider.

(iv) Mathematically we can follow:
a) the cosmological approach, starting from quantum wave functions describing proteins or crystals but extending them by loop quantum cosmology, **LQC.** This is started in this paper, but not shown rigorously. Nevertheless, this is highly encouraged to do so by stronger physicists.
b) However, also a string treatment is possible and not shown here. My impression is that this will be even stronger, but much tougher as it has to deal with n-dimensional strings, strings of any dimension and how they can interact at all.
c) We show that the nD-string interaction potential to allow a solid state of quanta, so allowing decoherence in our observed world, is challenging to calculate, however, if we follow the hint that interaction is also only a type of calculation and implement it for LQG as demonstration, there is already since 1898 the Hurwitz theorem showing that then only 1D, 2D, 4D and 8D (octonions) are possible, no other dimensions or symmetries are possible. However, the richest solution is actually the observed symmetry of our universe, E8. This is the strongest result of this paper in terms of mathematics.
d) what is not explored here in detail, but also very attractive, is a direct solid-state physics approach: Calculating the condensed state of quanta compared to the free, standard quantum treatment. The decoherent state is envisioned here as resulting from the fact that in the quantum soup much more chaos is there, strings of any dimension are possible and hence the vacuum energy can be so high. So we advocate here rather calculation of an nD-string pairwise interaction potential (maybe first the easier LQG calculation as above) and how this

grows to a full crystal instead of the old Dirac trick of cancelling out infinities. This old trick applies only if it is already given (in our domain) that you are in the bound state.
e) Solid state physics unites quantum theory and general relativity: Quantum physics and the coherence of all states at once applies only to the quantum soup outside our universe, inside our universe the macroscopic bound state is there, each state is nicely separated and real ("decoherence") and hence here, inside the crystal general relativity holds ("solid state"), outside is boiling quantum soup ("liquid state", coherence) prevents this. As the crystal is not perfect solid, there remains some liquidity and we still can experience in our crystal also the quantum world within our crystal, which is full-blown "outside" of our domain.

Concluding Discussion

Our theory replaces Big Bang and inflation by a start triggered from Qubit decoherence and subsequent magnetization or crystal-like growth of such a condensation nucleus replacing inflation. Our theory is well compatible with observation as after these very early events the standard model takes over, the textbook version of a hot, energetic fireball that expands.
Philosophically, our theory is very attractive as we no longer live in an absurd, strange universe (Adams, 1979) which started for no reason or as everything is possible in a mindboggling myriad of universes (Hawking and Hertog, 2006). Instead, our domain of observation, the universe we live in, is a layer in an abstract crystal. The beauty of the wave function is perfect, but our universe did arise from a bound qubit state with a finite number of states and hence, it is not perfect. Crystals come and go, also our crystal is swimming in a quantum soup ocean. It became self-ordered and life-friendly by selection during many generations. Nothing is forever, but everything lives in a cycle of creation and dissolution and is in harmony with nature. I leave it to the reader to realize that in my theory *god does not play dice* and this should for philosophical and religious reasons be so (I am agreeing with Einstein or, if preferred in the reader´s opinion, also with John´s gospel 1:1). According to this theory, there is no "blind watch maker" but everything evolves according to a clear plan, only we will never know it (ok, a bit old-fashioned, almost Newtonian or Leibniz-like, however, all is modern and based on qubits).

Regarding physics, new and central are four points:

(i) Laws of nature stable by crystal symmetries and not by inflation: Instead of an inflation guaranteeing the same laws of nature everywhere we have the same unit cell and symmetries properties everywhere as a crystal is created. This creates also less perturbations as the inflation, is hence better compatible with observation and stops softer similar to magnetization zones in a magnetic solid.

(ii**) The Big Bang singularity is replaced by qubit decoherence from boiling vacuum:** this theory does not start form nothing but assumes that the quantum foam can either be coherent or interact to become decoherent. The latter process can be described by formulas, the Hurwitz theorem allows to derive that there are only four solutions possible, and an octonion solution yields E8 symmetry as richest solution, fitting our own world. Further, for all other processes sketches of the cosmological formulas are provided.

(iii) **Approach attractive for theoreticians and demonstrated for LQG:** The explanatory power of the theory is high and includes evolutionary processes of several crystal generations explaining fine-tuning. Moreover, we suggest accurate tests of the theory though it is a cosmological theory and fixing its currently still too many free parameters by rather mundane laboratory tests on crystals including their formation and breakage, protein folding and quantum computer noise estimates (Zhou et al., 2020). The theory is attractive for many cosmological

approaches. Most of all this applies to LQG as pioneered by Smolin (1997), Ashthekar (2006) and others as throughout such concepts from LQG and LQC were used in its development. Moreover, as we only replace inflation and big bang by more tamed processes such as magnetization instead of inflation and loop quantum vacuum interaction instead a singularity at start, this theory should be attractive for cosmologists in general, in particular for soft or inflation-less scenarios. The novel "it from qubit" theory is closely related to my concept and there are interesting connections to emergent gravity (Verlinde, 2017). These are main connections of our theory, furthermore there are evolutionary scenarios and others.

(iv) Accurate parametrization possible by studying solid-state physics of crystals, proteins and quantum computers: This is only a first glimpse of what would be possible using our new perspective on cosmology (Figures 1-4). The mathematical details rely currently heavily on LQG and have to be worked out more concrete by experts in the field. Attractively, we can use everyday phenomena such as crystallization, magnetization, protein folding and quantum computing to identify correct parameters for their application of LQG to cosmology such that observations from these systems as well as cosmological observations are correctly matched. Most accurate would be validation and further development by string theorists but here the mathematics is most challenging.

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Box I (Intro 2)**: Why is qubit decoherence cosmology attractive and should be explored?**

Current cosmology appears strange and absurd and, in fact, is in trouble as current observations do not fit. Turbulences of inflation should be observed, but they turn out to be not there (e.g. BICEP2 experiment). Gigantic clusters of galaxies form, but nobody can explain how this is possible by a start from a flat, even universe.

This is no surprise: How should a "Big Bang" out of no reason explain anything?
Worse, as then "everything is possible", you have to rely on inflation to explain why you can have the same laws of nature everywhere in the universe.

Hence, please consider how normal creation processes works:
Proteins can only form and adapt their wonderful ordered structure because outside (in the water of the cell) the entropy increases.
Normal, mundane Crystals grow and they do this NOT by inflation but by ordering themselves according to the same unit cell and this guarantees that everywhere the same symmetries hold in the same crystal.

Apply the same reasoning to our universe as a whole: There was qubit decoherence, the wild vacuum boiling state did stop, there was an interaction (see below, Hurwitz theorem explains how) of the loop quantums and from this **condensation nucleus** more layers of loop quantums from the boiling soup become magnetized and create a larger crystal. After this *first period*, the decoherent qubits have together formed an almost completely solid crystal which then is ordered, has emergent space and time, and hence, according to general relativity, has to expand.
This explains why we have everywhere the same laws of nature and not the wrong assumption of an inflation period for this *first period*.
Minor displacements, so abundant in every real crystal, explain why you have so early on large galaxy superclusters and galaxies also surprisingly fast forming.

Crystals come and go, and there is hence a selection for ordered, self-organizing crystals as they are more stable and provide more condensation nuclei for the next generation – this explains the fine-tuning problem, why our universe is so self-organized and life-friendly. The standard explanation, that this is one of the strangest universes we live in is itself rather strange and absurd and not at all convincing.

We tackle an even more important point: Our reality, the mystery of decoherence.
The absolutely fascinating point about my new look at the universe is that Qubit decoherence explains both the start of the universe – so not from nothing but from the boiling quantum chaos after interactions are favorable – as well as why the decoherent state, our reality, is so stable in the macroscopic world:

The crystal formed in its ordered structure from the ocean of boiling loop quantum foam. We can show that if loop quanta (or strings) interact, they only can do so in the four ways shown by the **Hurwitz theorem**. However, a 1, 2 or 4-dimensional solution is not rich, so any interesting universe (e.g. with stars or with life) has to be 8-dimensional, and this is the universe we live in according to observations (actually an E8 symmetry).

This theory gets the vacuum energy right, as it calculates it for the decoherent, solidified, bound state of qubits and not, as textbook does, 10^{20} higher. The latter calculation is correct,

however, according to this theory it applies only to the boiling vacuum outside our world (the ocean in which the crystal swims in).

Moreover, **quantum computer experiments allow to check and work out the details** of my theory, as they move between both the coherent (calculation) and decoherent state (output). Finally, once you realize that the basis of our universe is only a set of qubits you can get rid of the mind-boggling and again completely wrong Everett multiverse: There is no splitting with every decision, you just have n qubits which each can have m states. There is only one universe and crystallized, solidified and hence became real: our world and its world line is one trajectory, one slice of this crystal, but the whole crystal is only n qubits with m states.

This is a fresh perspective on fundamental physics, it finds the solution how you can connect quantum physics with general relativity just by solid state physics.
Quantum physics is outside of the crystal, and inside of the crystal (so in our everyday world) only for everything smaller then Planck´s quantum as this is the remaining liquidity in the otherwise solidified crystal, the qubits became decoherent and have their n^m states now nicely separated and hence "real", i.e. decoherent. General relativity (GR) holds only inside the crystal, outside the vacuum boils, only a background-free treatment by loop quantum gravity, LQG is possible.

Mathematically, the theory needs to be developed much further. However, it offers attractive routes to explore for LQG and string theoreticians. In particular we have now with this fresh perspective **independent possibilities to parametrize these nice theories according to observations of mundane phenomena** such as protein folding and crystal formation. This is a wonderful way out of the 10^{600} possibilities to formulate string theory – but I need help here, the LQG treatment at least I can start to tackle, but string theory is simply too complex for me, though this is the mathematically more elegant and comprehensive theory. However, apart from everyday physics we offer attractive insights for astrophysicists, as they now can better understand what they observe, and for quantum computing experts as their experiments will help to correctly parametrize our theory again by a different angle and phenomenon which we really can control and do experiments with. This is actually the main bonus of this fresh perspective: we can probe it by other means then just cosmology and elementary particle physics. We offer also interesting insights for emergent gravity theoreticians and *aficionados* of evolutionary scenarios. Moreover, Big Bang theoreticians and inflation experts can easily see that only small modifications of their impressive theories are necessary just to better accommodate my fresh perspective on our universe. Mathematically we treat: the initial condensation event and the Hurwitz theorem; the growth and limitation of the magnetization phase of the first period; crystal breakage rate, derivation of basic nature constants, discussion of the AdS/CFT correspondence and, of course, qubit decoherence and multiverses.

Table 1. Concept: Unify general relativity with quantum physics by solid state physics

1. Big Bang singularity is replaced by a condensation event of interacting strings, transition from an uncontrolled, chaotic soup ("before") to a clearly interacting "real world".

2. Cosmological inflation scenarios are avoided. Long-range interactions inside this crystallization event limit growth and crystal symmetries ensure the same laws of nature and basic symmetries over our domain.

3. Tiny mis-arrangements present nuclei of superclusters and galaxies and crystal structure leads to the *correct arrangement of dark (halo regions) and normal matter* (galaxy nuclei) so convenient for galaxy formation.

4. Crystals come and go, allowing even an *evolutionary cosmology* where entropic forces from the quantum soup "outside" of the crystal try to dissolve it. This *may explain dark energy* and leads to a big rip scenario in 70 Gy.

5. Preference of crystals with *optimal offspring* and growth may select for self-organizing processes within the crystal and *may explain "fine-tuning"* of the local "laws of nature" to be favorable for life and intelligent observers.

6. A crystallization event may *explain quantum-decoherence in general*: The fact, that in our macroscopic everyday world we only see one reality.

7. In our crystallized world *the vacuum no longer boils but is cooled down* by the crystallization event and hence is 10**20 smaller, exactly as observed in our everyday world.

8. As we live in a "solid" state, within a crystal, the different quanta which build our world have all their different states nicely separated. This theory postulates *there are only n quanta* and m states available for them, *there is no Everett-like ever splitting multiverse* after each decision.

9. In the solid state we live in, there is decoherence, one clear development of a world, while the layers of the crystal are different system states and the edges different world trajectories.

10. Interaction potentials for strings or membranes of any dimension allow a solid state of quanta, so allowing decoherence in our observed world, are *challenging to calculate*.

11. If any type of physical interaction of strings corresponds just to a type of calculation, the *Hurwitz theorem shows* that then only 1D, 2D, 4D and 8D (octonions) allow complex or hypercomplex number calculations. The richest solution octonions, is actually *the observed symmetry of our universe, E8*.

Table 2. Self-organizing processes which are replicative processes

1 Top level: Self-organized highly ordered crystal with offspring → enhances the probability of such processes to reoccur fractally within itself (heuristic suggestion).

2 Weiss domain growth goes to infinity if there are no long range forces limiting the growth (at least in real magnets); a similar self-limiting growth for this cosmological scenario can of course be calculated but is really challenging.

3 Galactic level: Dark matter leads to collapsing of gas clouds which otherwise will never collapse (1 out of 10 rule, also correct for normal clouds; is well studied for real clouds and there are confirming data on galaxy formation from intergalactic hydrogen clouds)

4 Solar level: Supernovae trigger star bursts (calculations are available)

5 Individual level: Intelligent life creates new offspring but also new suns, new galaxies and new universes…(speculative)

Table 2. Validation Possibilities

a) Experiments:

--BICEP/2 Experiments speaks against Inflation
--Experiments with real crystals and proteins compared to the derived cosmological formulas for the formation of the abstract crystal underlying our domain
--Distribution of dwarf galaxies, dark and normal matter (would need far more mathematics added to the theory to derive testable predictions)
--Quantitative Magnetization experiments (also idea that long-range potential starts only after some more solid compactification), comparing classical magnetization with the cosmological scenario of Weiss domain growth and this again with estimates for early universe and cosmology in general.
--Self-organizing processes and their probabilities (would need far more mathematics added to the theory to derive testable predictions)
(sorted according to the challenges to really do them, BICEP/2 is done already)

b) Theoretical calculations:
--The quantum h, and velocity of light can be derived from the theory if the mathematics is done properly (see section 5 and 6)
- The same applies to dark matter and dark energy but here much tougher (see results)
--Very attractive: comparison of the vacuum energy in classical calculation (10^{20} too high) versus calculation in the "bound" state of solidification, crystallization. The latter should give the observed low vacuum energy in our "crystallized" domain / universe

Figures legends

Figure 1. (a) nD-String interaction crate a condensation nucleus. Further grows (star) forms a crystal. Size limiting for the growth are long range interactions, a solid crystal results. This is a very abstract type of crystal and it is made of interacting nD-strings. Their interaction is only possible for the types of interaction allowed by the Hurwitz theorem. Within the crystal all states are well separated, no longer liquid as in the background quantum foam "soup" shown as transparent bubbles in the background (superposition of all possibilities). **(b) Crystal in ocean of string soup.** Only within h, Planck´s quantum, there is flexibility. outside: all is quantum fuzzy and the boiling soup of superposition no decoherence, all states at the same time. GR holds only within the crystal; only here there is a clear reality, a strong decoherence field as stable as the crystal. **(c) Dark energy allows to dissolve the crystal over time.** Entropic forces from the soup tug and grow. Beyond a threshold the crystal dissolves ("big rip"), only the quantum bubble soup remains. Crystals which create new condensation seeds before they dissolved should be selected over time (external time, not bound to the crystal stability).

Figure 2. **Dark matter and normal matter.** Crystals have two important entities (like NaCl salt): Dark matter and normal matter; for visualization of their specific interactions only these key ingredients are shown (however, in this abstract crystal and its E8 symmetry group far more ingredients are built in). The figure visualizes that both types of matter easily interact in the crystal (in particular via gravity). The proper distribution of dark matter is important for galaxy formation inside the crystal. Thus, in halo regions is the dark matter, this is necessary to have nuclei of dwarf galaxies and for normal galaxies.

Figure 3. World-lines. The layers of the crystal separated by h are the alternative worlds, within one quantum all is still "fuzzy", the elasticity of the crystal. Only here is a defined time-trajectory for each layer, each "fate" of the world in one layer of the crystal (indicated by the slightly different trajectories), only small decisions are different. See also Figure 4 for a more detailed view.

Figure 4. Time reborn inside the crystal. The crystal (box with black rims) is just the freezing out of the quantum states of m quanta which can be each in n states. For illustration, this is shown for 6 quanta (“world” made of 6 quanta) which each can have 2 states (blue up or down arrow). Direction of higher entropy (thick blue arrow on the right) provides an arrow of time for each trajectory connecting system states as edges. Just as these quanta have in the free state all 6**2 states superposed, they have due to the string interaction potential in the solid state, i.e. the “frozen-out” state, simply all these accessible quantum states separated from each other („decoherent“). There is no splitting after each decision or other strange things happening as in Everett-type models of our universe: there are just a clearly defined number of quanta in solid state instead of the liquid coherent state. Left: System states with the same entropy are „close by“ in the crystal and the entropy gradient forms an internal (within the crystal) arrow of time (blue arrow). A specific world line or world trajectory is shown by the three black arrows.

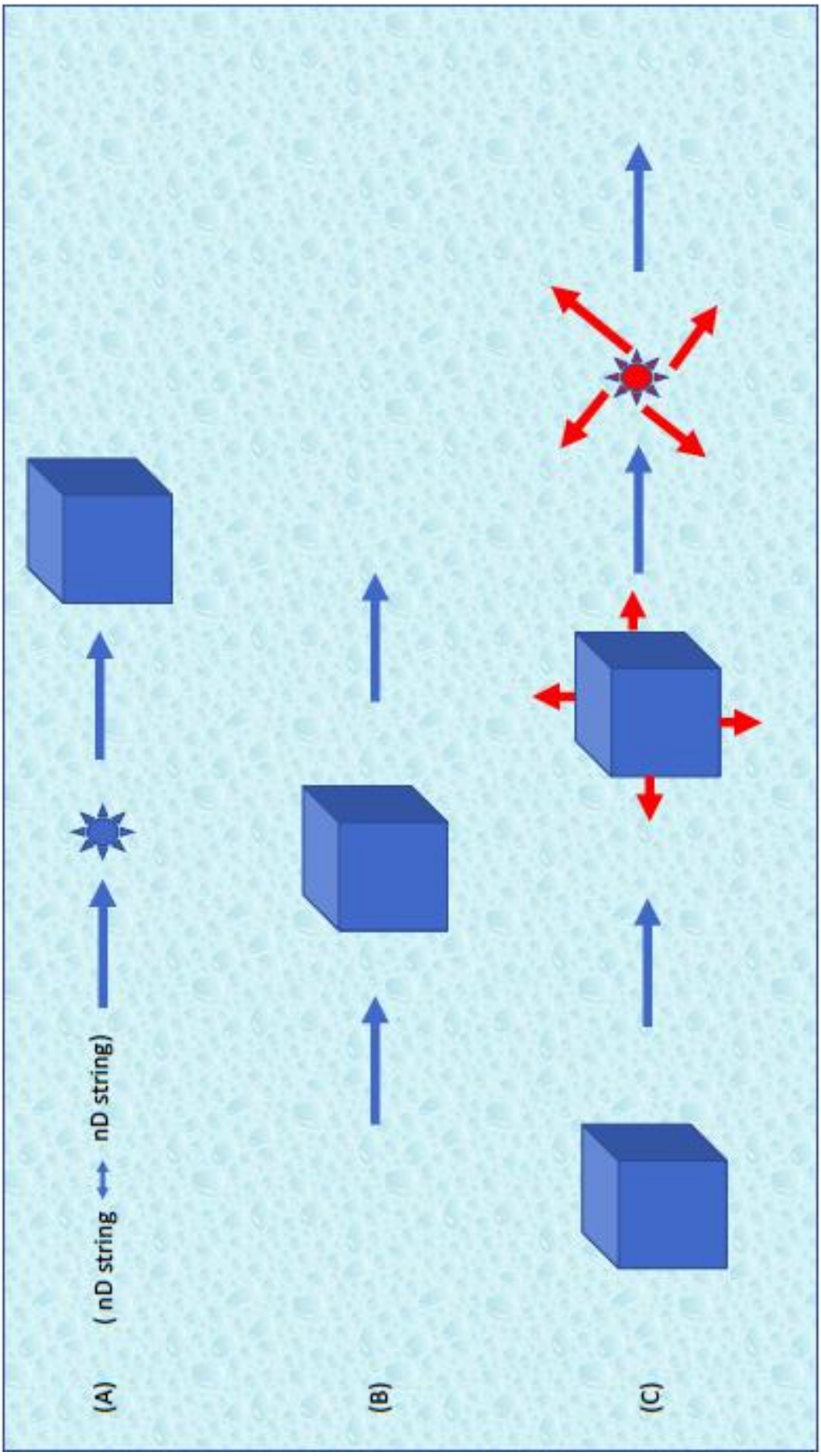

Fig. 1

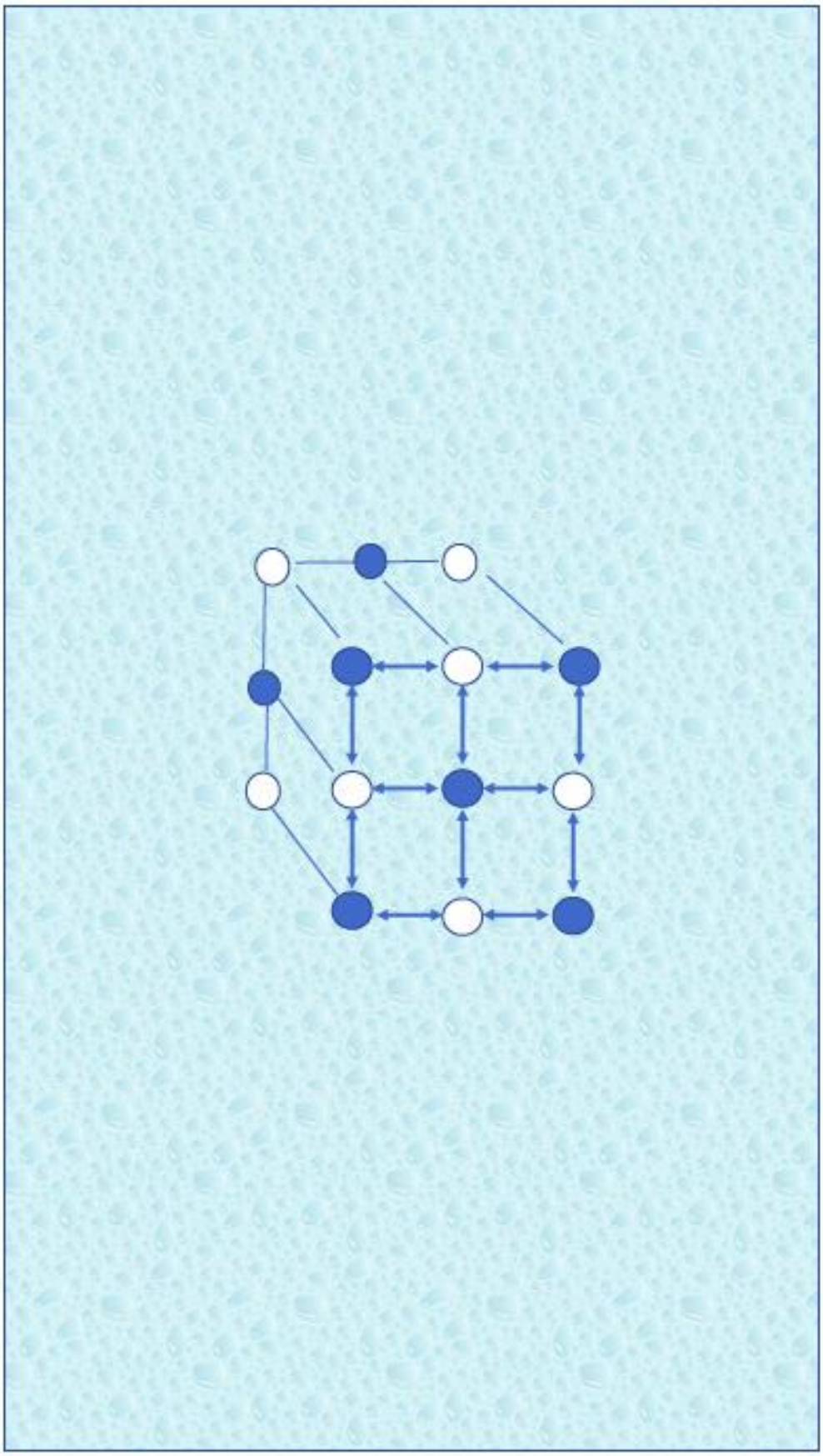

Fig. 2

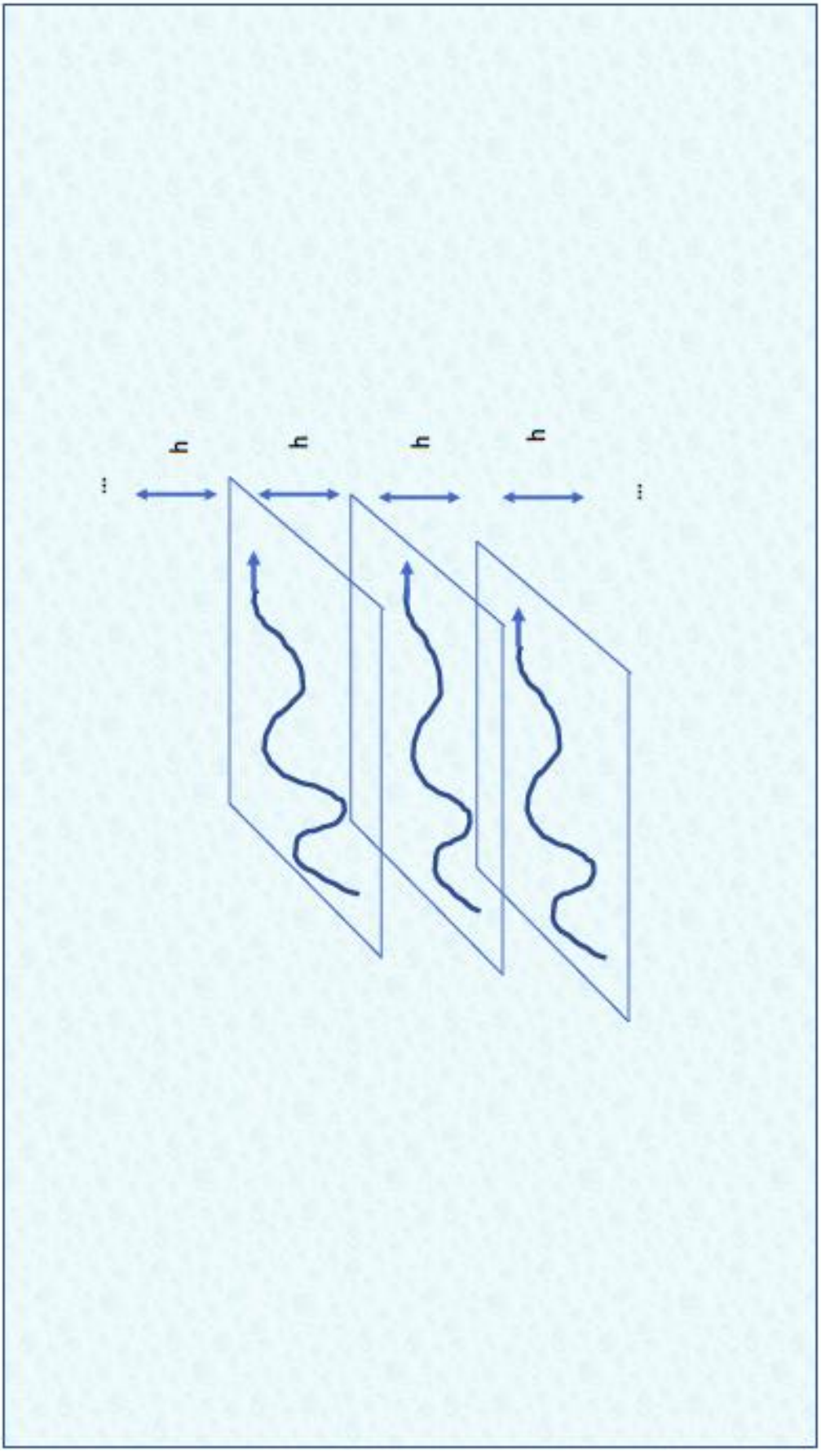

Fig. 3


Entropy
(arrow
of time)
System
states
top energy
high energy
middle energy
low energy

Fig. 4